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See Advertisement page 33.

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See Advertisement page 60, Feb. 6. 2402

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Engineering Salesmanship and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Millgate Building, Manchester. 2676

TENDERS.

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY CO.

The Directors are prepared to receive up to Noon on Wednesday, 25th February,

Tenders for the Supply of :—
1. BOLTS, NUTS AND RIVETS.
2. CHEMICALLY DRESSED WAGON COVERS, ETC.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices on payment of 20s. each for No. 1 and 10s. each for No. 2 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France, Westminster, S.W.1.
9th February, 1925. H 188

BELFAST HARBOUR.

THE BELFAST HARBOUR COMMISSIONERS invite

Tenders for the Construction, ERECTION and SETTING TO WORK of ONE ELECTRICALLY-DRIVEN TRAVELLING CRANE (3-phase A.C., 380 volts, 50 cycles). The Crane is to be erected on the Abercorn Basin, Belfast, where pointed out.

Outline Specification, Form of Tender, and any further information required may be obtained from the Harbour Engineer, Mr. T. S. GILBERT, M.Inst.C.E.

Tenders must be made on the Special Form provided for the purpose, and enclosed in a sealed envelope, addressed to the undersigned and endorsed "TENDER FOR ELECTRIC CRANE," and delivered on or before Wednesday, the 11th March, 1925.

The Commissioners do not bind themselves to accept the lowest or any Tender.

M. J. WATKINS,
General Manager and Secretary.

Harbour Office, Belfast, 6th February, 1925. H 179

THE BURMA RAILWAYS CO., LTD.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of :— INDUCTION MOTOR AND STARTING PILLAR.

For each copy of the Specification a fee of 20s. will be charged, which fee is not returnable. Tenders, enclosed in sealed envelopes, addressed to "The Chairman and Directors" and endorsed "Tender for Induction Motor, etc.," must be delivered at the Company's Offices not later than Twelve Noon, on Wednesday, 25th February, 1925. The Directors do not bind themselves to accept any or the lowest Tender and reserve the right to divide the order.

All the work is urgently required in Burma.

By Order of the Board.
F. C. FRANKS,
Secretary.

199, Gresham House, Old Broad Street, London, E.C.2.
13th February, 1925. H 184

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of :— STEELWORK FOR BRIDGES.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tender for Steelwork for Bridges," must be left with the undersigned not later than Twelve Noon, on Friday, the 17th April, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of the Specification.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
10th Feb., 1925. H 203

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, invites

Tenders for :—
1. WHEELS AND AXLES. 1000 pairs.
2. BODY IRONWORK for railway carriages, 13 sets.

Tenders due on Friday, the 27th February, 1925, for No. 1, and on Friday, the 6th March, 1925, for No. 2.

Tender Forms obtainable from above. H 203

METROPOLITAN ASYLUMS BOARD.

TO HEATING AND HOT WATER ENGINEERS.

The Board invite

Separate Tenders for
(A) The INSTALLATION of a FORCED CIRCULATION HOT WATER SUPPLY SYSTEM in the Schools' Section of Darenth Training Colony, Dartford, Kent.
(B) The INSTALLATION of HEATING APPARATUS at St. Anne's Home, Herne Bay,

each in accordance with the Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawings and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m. on Wednesday, 11th February, 1925, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 25th February, 1925.

G. A. POWELL,
Clerk to the Board. H 163

APPOINTMENTS OPEN.

RESEARCH DEPARTMENT.
ROYAL ARSENAL, WOOLWICH.

DIRECTORATE OF METALLURGICAL RESEARCH.
ASSISTANT II (Temporary).

Required, One Temporary ASSISTANT, Grade II. Should be graduate with University training in Metallurgy and some years experience of metallurgical research. Initial salary £250 and bonus. Total emoluments at present £369 2s. Leave at the rate of 36 days per annum.

JUNIOR ASSISTANT (Temporary).

Required, Metallurgist. Should be a graduate who has received a University training in Metallurgy. Initial salary £160 and bonus. Total emoluments at present £252 5s. Annual leave 24 days.

Some years experience in metallurgical analysis would be an additional qualification for either of the above posts. Ex-service men, if suitably qualified, will be preferred for both appointments.

Applications in writing, accompanied by copies of not more than three testimonials, should be made to the

CHIEF SUPERINTENDENT,
Research Department,
Royal Arsenal,
Woolwich, S.E.18,

from whom conditions of employment may be obtained. H 201

COUNTY OF SURREY.

HIGHWAYS AND BRIDGES DEPARTMENT.

CROCKFORD BRIDGE RECONSTRUCTION.

Applications are Invited for the APPOINTMENT of CLERK OF WORKS to act under the directions of the County Surveyor to take charge of the works comprised in the reconstruction of Crockford Bridge, Addlestone, which is being done under Contract. Salary at the rate of £6 per week.

Applications in writing, stating full particulars of appointments held and experience on bridge and reinforced concrete works, accompanied by references, should reach the undersigned not later than Friday, the 20th February, 1925.

Forms of applications and further particulars may be obtained from the undersigned. Stamped addressed envelope should be forwarded.

W. P. ROBINSON, Assoc.M.Inst.C.E.,
County Surveyor,

County Hall, Kingston-on-Thames,
6th February, 1925. H 164

INDIAN SERVICE OF ENGINEERS, STATE RAILWAYS.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will, in 1925, appoint

Two Assistant Executive ENGINEERS for this Service if so many suitable candidates present themselves.

Every candidate must be a British subject or a ruler or subject of any State in India in respect of whom the Governor-General of India in Council has made a declaration that he is to be considered eligible.

Candidates must be not less than 21 years and not more than 24 years of age on 1st August, 1925.

They must either (1) have obtained one of certain recognised University degrees or other distinctions in Engineering, or (2) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers or been exempted by the Institution from such examination, or (3) produce the required evidence that they are otherwise eligible under the Regulations. They must in addition have had at least one full year's practical experience of Civil Engineering under a qualified Civil Engineer at the time when they appear before the Selection Committee.

Applications from candidates must reach the India Office not later than 1st April. Printed forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, PUBLIC WORKS DEPARTMENT, India Office, Whitehall, London, S.W.1. H 161

Superintendent Engineer REQUIRED, with civil and mechanical training, preferably Associate Member of recognised Institution, competent to manage Workshops and Maintenance Plant, including Power Plant, Machine Shops, Electricians, Smiths, Joiners, Bricklayers, in important Works in a district accessible to Manchester and Liverpool and engaged in a branch of the Steel Industry.

Experience in machinery for Rod Rolling, Wire-drawing and ancillary trades an advantage.

Replies to be typewritten, stating age, qualifications, experience and salary required.—Address, H 159, Offices of ENGINEERING.

Section Engineers (6) REQUIRED for the Construction Branch of the FEDERATED MALAY STATES RAILWAYS for three years' service with possible extension. Salary $400 a month rising to $475 a month by annual increments of $25 a month plus a temporary non-pensionable allowance of 10% which is liable to cancellation or revision, plus a commuted Field Allowance of $50 a month. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d. but its purchasing power in Malaya is at present considerably less than that of 2s. 4d. in the United Kingdom. Free passage provided. On expiration of agreement a bonus of four and a-half months salary may be allowed provided the work and conduct of the person engaged has been in every way satisfactory. Candidates, age 25 to 38 and unmarried, must be fully qualified Railway Engineers who have received good training and experience on recognised European, American or Colonial Railways. Members or Associate Members of the Institution of Civil Engineers preferred.—Apply, at once by letter, stating age and particulars of qualifications and experience to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting at top of application M/1/264. H 82

BOMBAY, BARODA & CENTRAL INDIA RAILWAY.

TEMPORARY ASSISTANT ENGINEER for SIGNALLING AND ENGINEERING WORKSHOP, BOMBAY.

The Directors are prepared to receive

Applications (by letter only) from properly qualified candidates for the above POST, who must be qualified Interlocking and Signal Engineers, and be able to establish and manage a small workshop for the manufacture and reconditioning of Signalling and Interlocking material. The shop will consist mainly of Smithy, Carpenter's Shop, Fitting and Connecting Shop, Machine Shop and Stores Yard.

SALARY :—Rs. 750 per calendar month, plus local allowances according to the scales in force.

TERMS :—A three years' agreement, first-class free passage to India, and home again on satisfactory termination of services.

The selected Candidate will be required to pass a strict medical examination by the Company's Consulting Physician before appointment.

Applications should give full particulars of age, whether married or single, where apprenticeship or pupilage was served, with special details as to the applicant's experience as an Interlocking and Signal Engineer, and of the work he has carried out in the actual manufacture and reconditioning of Signalling and Interlocking material. These particulars should be received by the undersigned not later than the 28th February, 1925.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion, 91, Petty France, Westminster, S.W.1.
11th February, 1925. H 224

Wanted, Research Assistant to Prof. Andrew Robertson. Honours Degree in Engineering essential.—Apply, Prof. ANDREW ROBERTSON, Merchant Venturers' Technical College, Unity Street, Bristol. Salary £250 to £300. H 211

Estimator Required, Capable of making estimates from project drawings for mechanical handling plants for coal and other materials. Only men with good experience and proved abilities need apply. State age, experience and salary required.—Address, G 752, Offices of ENGINEERING.

Estimator Wanted for Engineering WORKS; must be capable all-round man, shop trained, with drawing office experience, and be able to work out weights and prices of light and heavy castings, all kinds of structural work, mining and general machinery. None but first-class men need apply.—Write, stating age, experience and salary required, BOX 543, SELLS' Advertising Offices, Fleet Street, E.C.4. H 205

Cement Works Manager's Understudy, Country, with some practical Chemical, Electrical, Mechanical and Engineering Training. Age 30-40. State education, experience, commencing salary, etc.—Address, H 101, Offices of ENGINEERING.

Ratefixer Wanted with Experience piece-work prices machinery fitting and erecting various classes engine work. Only those with proved experience need apply.—Write, stating age, salary required and full particulars experience, BOX 546, SELLS' Advertising Offices, Fleet Street, E.C.4. H 209

Steam Turbine Designer.— REQUIRED ASSISTANT DESIGNER accustomed to Steam Turbine Work. Must possess Drawing Office, Shop and Design experience.—Applicants should give full particulars, mentioning also age and salary required, to W. H. ALLEN, SONS AND CO., LTD., Bedford. H 220

Draughtsman Wanted, with experience in electric traction motors and control gear. State age, experience and salary required, to TRACTION DEPT., B.T.H. Co., Ltd., Rugby. H 215

Wanted, Draughtsmen with good all-round mechanical experience, Engines (I.C.), Air Compressors, Hydraulic. London district.—Address, H 218, Offices of ENGINEERING.

Draughtsman Wanted, used to refrigerating lay-out and machine design. State experience and salary.—Address, H 36, Offices of ENGINEERING.

Designing Draughtsman REQUIRED in connection with coal and mechanical handling plants. Only men with complete knowledge and first-class experience need apply. State age, experience and salary required.—Address, G 752, Offices of ENGINEERING.

Draughtsman Required, thoroughly used to estimating, designing and measuring up for Constructional Steelwork.—Address, stating age, experience, salary required, H 180, Offices of ENGINEERING.

Required Immediately, Two Shop-Trained DRAUGHTSMEN, aged about 25. Preferably with experience of Elevating, Conveying and allied machinery.—Address, H 190, Offices of ENGINEERING.

Competent Draughtsman and DESIGNER REQUIRED, accustomed to modern Laundry Machinery.—Address, stating age, experience and salary required, H 165, Offices of ENGINEERING.

Draughtsman Wanted, Only those with large experience in Colliery Winding, Haulage and other Mining Machinery need apply. State age, experience and wages required.—Address, H 171, Offices of ENGINEERING.

Draughtsmen Required with experience in design of Steel Works or Glass Works Furnaces.—Reply fully to STEIN & ATKINSON, LTD., 47, Victoria Street, S.W.1. H 173

Draughtsman Required for general lay-out work in factory near London. State age, salary required and full particulars of experience.—Address, H 192, Offices of ENGINEERING.

Draughtsman Wanted, Accustomed to design of mining and concentration machinery.—Apply, stating age, experience and salary required, to FRASER & CHALMERS' ENGINEERING WORKS, Erith, Kent. H 208

Wanted, First-class General Arrangement DRAUGHTSMAN for project work for Boiler Installations.—Address, stating age, experience, salary required, etc., H 210, Offices of ENGINEERING.

Draughtsman for Constructional Work. General engineering experience necessary; also some knowledge of colliery plant. Age, 24/30. Salary 500/600 rupees per mensem.—Call, C. W. PETTY & COMPANY (Appointment Specialists), 58, Haymarket, S.W.1. 'Phone: Gerrard 6647. H 225

Wanted, Foreman for Tube works, experienced in manufacture steam main, high pressure pipes. Wednesbury district.—Address, H 168, Offices of ENGINEERING.

SITUATIONS WANTED.

Cost Accountant, With First-class wide experience in large manufacturing concerns of repute. All branches of engineering in up-to-date methods. Excellent personal and commercial references. — Address, H 63, Offices of ENGINEERING.

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PRACTICAL NOTES ON THE THEORY OF THE MICHELL BEARING.

By W. R. NEEDHAM.

THE present writer lays no claim to originality in what follows. For a thoroughgoing, full-dress exposition the reader should consult such recognised authorities as A. G. M. Michell himself, or H. M. Martin. Thus he may turn up Michell's original article, entitled "Lubrication of Plane Surfaces," *Zeitschrift für Mathematik und Physik*, 1905,* or he may read an article by Martin on "The Theory of the Michell Thrust Bearing," which appeared on page 233, ENGINEERING, February 20, 1920.

The notes here presented are written more from the practical, as distinct from the academic, standpoint. Consequently, the proven results of the theorists are accepted. Deductions and certain amplifications deemed to be of practical use are offered while occasion arises to correct one or two numerical slips which appear to have crept into the sources acknowledged.

Fig. 1 illustrates the principle of the tilting pad or slide block. It is the figure which readers of the original articles will readily recognise. The pad is so pivoted that when in commission it accommodates the wedge-shaped oil film, which practice and theory alike prove to be the most effective and efficient medium yet discovered for securing satisfactory lubrication. Under conditions of loading and velocity otherwise regarded as entirely prohibitive, the shaft collar or journal is completely oil borne, thus obviating metallic contact of opposing surfaces. Consequently the friction loss is but a fraction of that which obtains in the case of non-tilting designs. The essential provision is that the pad automatically assumes the correct tilt needful to the most efficient functioning. Thus in the illustration, the "shaft rotates" in the plane *a b c d*, while the pad is tilted therefrom at an angle θ. The relative motion of the under or "shaft" surface is U cm. per second. The pad length in the direction of motion is L cm., while its width (transverse to the motion) is W cm. The pad, as shown, is so disposed that the distance from 0 to its remote limit or leading edge is 2L. The leading edge is, of course, that which heads on to the rotation.

It is possibly of interest to point out that Michell, taking Osborne Reynold's case of the infinitely wide slide block, shows, in a comprehensive table for different $\frac{\text{O to leading edge}}{\text{O to trailing edge}}$ ratios, that the thickness of lubricant (or oil film) at the trailing edge is a maximum when that ratio is 2·2. Reynolds had shown that, under such conditions, and for that particular ratio, the greatest mean pressure for a given mutual inclination (θ) of surfaces was secured. In much subsequent work it has been considered sufficient to deal with the case in which this ratio is 2·0.

The short Table I given below is abstracted from fuller data given by Mr. Michell.† It shows actual

TABLE I.

0 to Lead. Edge / 0 to Trail. Edge.	Oil Film Thickness.		Relative position of centre of pressure from Trail. Edge.	Effective Co-efficient of Friction.
	Trail. Edge.	Lead. Edge.		
	c.m.	c.m.		
1·0 ..	0	0	0·5000	∞
1·4 ..	0·3465×10⁻³	0·4851×10⁻³	0·4664	2·428×10⁻³
1·8 ..	0·3995×10⁻³	0·7119×10⁻³	0·4416	1·858×10⁻³
2·0 ..	0·4026×10⁻³	0·8051×10⁻³	0·4313	1·722×10⁻³
2·2 ..	0·4043×10⁻³	0·8895×10⁻³	0·4221	1·625×10⁻³
2·4 ..	0·4027×10⁻³	0·9665×10⁻³	0·4137	1·553×10⁻³
3·0 ..	0·3884×10⁻³	1·1652×10⁻³	0·3926	1·414×10⁻³
5·0 ..	0·3247×10⁻³	1·6237×10⁻³	0·3465	1·239×10⁻³
11·0 ..	0·2115×10⁻³	2·3269×10⁻³	0·2832	1·134×10⁻³

numerical results in C.G.S. units; where the resultant pressure is 1 kgm., and the fluid is of viscosity 1 C.G.S. The surface is assumed to be 1 cm. long in the direction of motion, and the results are expressed for one centimetre width.

* This may be consulted in the north library of the British Museum.

† Section on "Viscosity and Lubrication" in composite work entitled "Mechanical Properties of Fluids," Drysdale, and others.

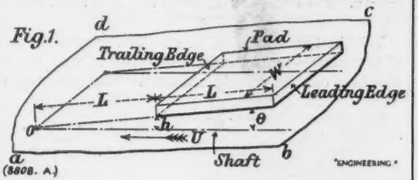
In what follows the ratio 2 is taken as a reasonable compromise for ordinary purposes of design.

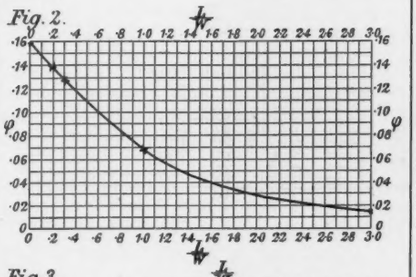
Reynolds has shown that the load per centimetre width which an infinitely wide block will sustain is

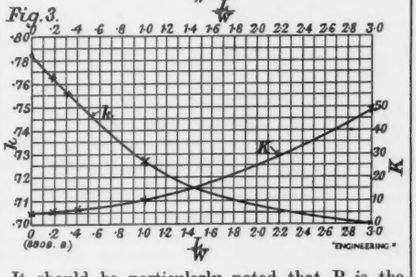
$$P = \frac{\lambda \cdot U \cdot L^2}{h^2} \phi \text{ dynes} \quad . \quad . \quad (1)$$

where λ is the viscosity of oil, in dynes per sq. cm.;
U is the relative velocity of opposing surfaces, in cm. per sec.,
L is the length of block in cm.;
h is the thickness of oil film at the trailing edge of block, in cm.;
ϕ is a co-efficient whose value is determined by the angle θ between opposing surfaces—it is 0·159 when the ratio $\frac{\text{O to leading edge}}{\text{O to trailing edge}} = 2{\cdot}0$

(Martin has pointed out that the denominator, given in Reynolds's original paper as h^3, is actually h^2.)







It should be particularly noted that P is the load per centimetre width, not the load per square centimetre.

Mr. Michell tackled the problem for the case of blocks of finite width—a much stiffer task. Thus, he dealt with a square pad π cm. $\times$ π cm., and also with a block 3π cm. long $\times$ π cm. wide.

From the data supplied by Reynolds and Michell, supplemented by some further calculations, the curve, reproduced in Fig. 2, was prepared and published in ENGINEERING, *loc. cit., sup.* In this ϕ is plotted against the ratio $\frac{L}{W}$ for the case in which the film thickness at the leading edge was twice that at the trailing edge.

Now, for such small angles as θ must necessarily be, and for the block edges ratio of 2·0, $\frac{h}{L} = \theta$ (practically). Thus, (1) can be written

$$P = \frac{\lambda U}{\theta^2} \phi \text{ dynes} \quad . \quad . \quad . \quad (2)$$

This is, perhaps, the more convenient form.

Keeping the same critical ratio of 2·0 in the article in ENGINEERING the frictional resistance was deduced over the whole block area (*i.e.*, the total shear in the oil film, as distinct from the shear per unit area). This can be written

$$R_{\text{total}} = \frac{L \lambda U}{\theta} \log_e 2 + \frac{L}{2} \cdot \frac{\lambda U}{\theta} \phi \text{ dynes} \quad . \quad (3)$$

whence the resistance or shear per centimetre width is

$$R = \frac{\lambda U}{\theta} \log_e 2 + \frac{\lambda U}{2\theta} \phi$$

$$= \frac{\lambda U}{\theta} (\log_e 2 + \tfrac{1}{2}\phi) \text{ dynes} \quad . \quad . \quad . \quad (4)$$

A numerical slip occurs here in the article, the coefficient for a block 0·6 cm. long, π cm. wide, being given as 0·911. Quite obviously, this clerical oversight arises from the omission to divide both factors, and not one only, to the right hand of (3), by L, or, in the case taken, by π.

Now (4) can be put in the form

$$R = \frac{\lambda U}{\theta} k \quad . \quad . \quad . \quad . \quad (5)$$

where $k = \log_e 2 + \frac{1}{2}\phi$.

For the case in point, $\frac{L}{W} = \frac{0{\cdot}6}{\pi}$, and $\phi = 0{\cdot}139$.

Consequently $k = 0{\cdot}6931 + \frac{0{\cdot}139}{2} = 0{\cdot}7626$ (instead of 0·911).

A relation of considerable practical interest is that which has regard to μ, the coefficient of friction.

Thus

$$R = \mu P; \text{ hence}$$

$$\mu = \frac{R}{P} \quad . \quad . \quad . \quad . \quad . \quad (6).$$

Now from (5) and (2) μ, obviously, becomes

$$\frac{\frac{\lambda U k}{\theta}}{\frac{\lambda U \phi}{\theta^2}} = k \frac{\theta}{\phi} \quad . \quad . \quad . \quad (7)$$

or, putting

$$\frac{k}{\phi} = K, \quad \mu = K\theta \quad . \quad . \quad . \quad (8).$$

Fig. 3 relates k and K to the base L/W between the limits 0 and 3. The data of Table II give the five steps upon which the graphs are constructed, and amplifies the particulars provided in the article in ENGINEERING. The k and K columns are new, and their entries have been calculated as just indicated. The two final columns are also new.

TABLE II.

$\frac{L}{W}$.	ϕ.	Relative position of centre of pressure from trailing edge of Block.	k.	K.	C.	C. English.
$\frac{0}{\infty}$ = 0..	0·159	0·45 / 0·431 per Michell	0·7726	4·86	1·94	0·0256
$\frac{0{\cdot}6}{\pi}$ = 0·191	0·139	—	0·7626	5·49	2·05	0·027
$\frac{1}{\pi}$ = 0·319	0·127	—	0·7566	5·96	2·125	0·028
$\frac{\pi}{\pi}$ = 1 ..	0·0667	0·42	0·7265	10·88	2·81	0·037
$\frac{3\pi}{\pi}$ = 3 ..	0·0146	0·39	0·7004	48·00	5·80	0·0763

K values, as expressed by Michell (Zeit. für Math. and Physik, 1905) are 4·86, 10·83, and 143 for L/W = 0, 1 and 3 respectively. It can be shown that the large discrepancy in the last-mentioned must be due to a numerical slip. Following Michell's general procedure, the answer for that example works out in accordance with the value tabled above (*i.e.*, 48).

Thus, he gives the mean pressure *per square cm.* (neglecting sign) as $0{\cdot}00155 \frac{\lambda U}{\theta^2}$. Consequently, the pressure per centimetre width for the entire length of 3π centimetres is,

$$P = 3\pi \, 0{\cdot}00155 \frac{\lambda U}{\theta^2}$$

$$= 0{\cdot}0146 \frac{\lambda U}{\theta^2},$$

which agrees with (2) for the particular example chosen. This is here the total pressure also.

Further, he gives for the total resistance of the whole block,

$$R_{\text{total}} = \frac{\pi \lambda U}{\theta} \log_e \frac{2L}{L} + \theta \frac{P_{\text{total}}}{2}*$$

* Michell omits this term in his latest treatise, *vide* "Viscosity and Lubrication" in the composite work "Mechanical Properties of Fluids." So doing, for the square pad he deduces K as 10·3 instead of 10·88. In the text, however, he calls attention to his earlier article for more detailed working out. It would seem to be an omission by inadvertence.

Now

$$\mu = \frac{R_{total}}{P_{total}} = \frac{\pi \lambda U}{P_{total}\,\theta} \log_e 2 + \frac{\theta}{2}$$

$$= \frac{\pi \lambda U}{\pi\ 0{\cdot}0146\ \frac{\lambda U}{\theta^2}\ \theta} \log_e 2 + \frac{\theta}{2}.$$

$$= (68{\cdot}6 \times 0{\cdot}6931\ \theta) + 0{\cdot}5\,\theta = 48\,\theta$$

which agrees with (8) when accorded the tabled value of K.

Engineers and designers generally are interested particularly in frictional resistance or oil film shear, pressure, velocity, and co-efficient of friction. All these relations have been expressed, notably in (2), (5) and (8).

The expressions, however, all involve the inclination of surfaces, or thickness of oil film. Now this term can be readily enough eliminated. The simplified expressions are eminently suitable for practical use. Thus, we can write, per (2),

$$\theta^2 = \frac{\lambda U}{P}\,\phi,$$

whence

$$\theta = \left(\frac{\lambda U \phi}{P}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad (9)$$

Further,

$$R = \mu P = K P \theta \quad . \quad \text{(See 8)}$$

$$= K P \left(\frac{\lambda . U . \phi .}{P}\right)^{\frac{1}{2}}$$

$$= K\,(\lambda . U . P . \phi)^{\frac{1}{2}} \text{ dynes per cm. width.} \quad (10).$$

If now we put $P = p\,L$, and $R = r\,L$, where p and r are the pressure and resistance respectively, *per unit area* (*i.e.*, dynes per square centimetre), then

$$r = \frac{R}{L} = \frac{K\,.\,(\lambda\,.\,U\,.\,p\,.\,L\,.\,\phi)^{\frac{1}{2}}}{L}$$

$$= K\,.\,\phi^{\frac{1}{2}} \left(\frac{\lambda\,.\,U\,.\,p}{L}\right)^{\frac{1}{2}} \text{ dynes/cm.}^2 \quad . \quad (11)$$

Writing $K\,.\,\phi^{\frac{1}{2}} = C$, (11) becomes

$$r = C \left(\frac{\lambda U p}{L}\right)^{\frac{1}{2}} \text{ dynes per square cm.} \quad (12).$$

Taking the case of the square block,

$$C = 10{\cdot}88 \sqrt{0{\cdot}0667} = 2{\cdot}81, \text{ whence}$$

$$r = 2{\cdot}81 \left(\frac{\lambda U p}{L}\right)^{\frac{1}{2}} \text{ dynes/cm.}^2$$

This agrees with Mr. R. O Boswall's formula.*

The co-efficient of friction also can be expressed in convenient form.

Thus

$$\mu = \frac{R}{P} = \frac{r}{p} = C \left(\frac{\lambda U}{p\,.\,L}\right)^{\frac{1}{2}} \quad . \quad . \quad (13)$$

English and American engineers doubtless prefer to work in English rather than C.G.S. units. Now, if we express r of (12), as regards the result only, in English values, we get

$$r = \frac{C}{69{,}000} \left(\frac{\lambda\,.\,U\,.\,p}{L}\right)^{\frac{1}{2}} \text{ lb. per sq. in.}$$

Converting the terms U, p and L respectively into U_E, p_E, and L_E, being feet per second, lb. per square inch, and inches, we then obtain

$$r_{English} = \frac{C}{69{,}000} \left[\frac{\lambda\,.\,(2{\cdot}54 \times 12\ U_E)\ (69{,}006\ p_E)}{2{\cdot}54\ L_E}\right]^{\frac{1}{2}}$$

$$= C \left[\frac{12}{69{,}000} \left(\frac{\lambda\,.\,U_E\,.\,p_E}{L_E}\right)\right]^{\frac{1}{2}}$$

$$= 0{\cdot}01313\ C \left(\frac{\lambda\,.\,U_E\,.\,p_E}{L_E}\right)^{\frac{1}{2}} \text{ lb. per sq. in.} \quad (14)$$

In this connection note that the viscosity λ is retained in C.G.S. units.

Similarly

$$\mu = 0{\cdot}01318\ C \left(\frac{\lambda\,.\,U}{p_E\,.\,L_E}\right)^{\frac{1}{2}} \quad . \quad . \quad (15).$$

If we put $C_{English} = 0{\cdot}01318C$, (14) and (15) become respectively

$$r_{Engl.} = C_{Engl.} \left(\frac{\lambda\,.\,U_E\,.\,p_E}{L_E}\right)^{\frac{1}{2}} \text{ lbs. per square inch} \quad (16).$$

$$\mu = C_{Engl.} \left(\frac{\lambda\,.\,U_E}{p_E\,.\,L_E}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad (17).$$

C and $C_{Engli\text{-}h}$ are given in the two final columns of Table II for the five typical cases mentioned. The graph, Fig. 4, is added for purposes of interpolation.

It is well known that for the exacting condition to be met with in much of modern steam turbine practice—high pressures and high velocities—relatively light oils are recommended. Pressures round about 350 lb. per square inch are probably a very fair average. Assuming p values between, say, 300 and 400 lb. per square inch, and a temperature controlled to keep within, say, 120 deg. F., it is possible to estimate a reasonably close value of λ for a light oil suitable for turbine usage. Thus, if within the pressure and temperature limits postulated, and for moderate to high velocities, we put $\lambda = 0{\cdot}200$, we shall probably be correct to within ± 7 per cent. For ordinary practical calculations this should answer well enough.

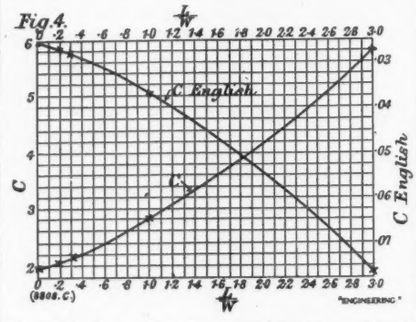
Thus, substituting this value of λ in (16) and (17), approx.,

$$r_E = 0{\cdot}45\ C_E \left(\frac{U_E\,.\,p_E}{L_E}\right)^{\frac{1}{2}} \text{ lb. per sq. in.} \quad . \quad (18)$$

$$\text{approx.} \quad \mu = 0{\cdot}45\ C_E \left(\frac{U_E}{p_E\,.\,L_E}\right)^{\frac{1}{2}}. \quad . \quad . \quad . \quad . \quad (19)$$

Within the same limits, and to the same degree of accuracy—or approximation—the friction loss at bearings can be readily assessed. The quantity of

Fig. 4.



oil required can also be approximated to, though here the limits of possible error are almost inevitably wider.

Now F, the work lost in friction *per pad* (approximately)

$$= 60\ r_E\ W_E\ L_E\ U_E$$

$$= 27\ C_E \left(\frac{U_E\ p_E}{L_E}\right)^{\frac{1}{2}} W_E\ L_E\ U_E$$

$$= 27\ C_E\ U_E^{\frac{3}{2}}\ W_E\ (p_E\ L_E)^{\frac{1}{2}} \text{ ft./lb. per minute} \quad . \quad (20)$$

$$= 0{\cdot}000819\ C_E\ U_E^{\frac{3}{2}}\ W_E\ (p_E\ L_E)^{\frac{1}{2}} \text{ Horse power} \quad (21)$$

Further, the heat developed (approx.)

$$= \frac{(20)}{778} \text{ B.Th.U. per minute.}$$

$$= 0{\cdot}0347\ C_E\ U_E^{\frac{3}{2}}\ W_E\ (p_E\ L_E)^{\frac{1}{2}} \text{ B.Th.U. per minute.}$$

Taking 9 lb. of oil to the gallon, assuming 0·375 as a rough mean value for the specific heat of oil, and putting T as the temperature rise of oil, in degrees Fahrenheit, the approximate quantity of oil Q, per pad,

$$= \frac{\text{Heat in B. Th. Units per minute}}{9 \times 0{\cdot}375 \times T}$$

$$= 0{\cdot}01027\ \frac{C_E}{T}\ .\ U_E^{\frac{3}{2}}\ W_E\ (p_E\ L_E)^{\frac{1}{2}} \text{ gallons per minute} \quad (22).$$

If we put T as 25 deg. F., which should be close enough for rough and ready purposes,

$$Q = 0{\cdot}000411\ C_E\ .\ U_E^{\frac{3}{2}}\ .\ W_E\ (p_E\ L_E)^{\frac{1}{2}} \text{ gallons per minute} \quad (23)$$

$$= (0{\cdot}503 \times \text{Horse Power}) \text{ gallons per minute} \quad (24)$$

It should be noted that the value of Q is in the very nature of things at best only a rough approximation. It has but to be remembered that the specific heat of different lubricating oils is given variously between limits of round about 0·3 and 0·5 to realise the appositeness of the caution.

It may be added that, for ordinary purposes, L of a segmental pad may be taken as the *mean* length.

In conclusion, a numerical example is given illustrating the use of the relevant graphs and formulæ.

The dimensions of a segmental pad are : $L_{mean} = 4$ inches, $W = 5$ inches. The mean intensity of pressure p_E is 350 lb. per square inch; the velocity U_E at the effective mean area circle of the pad surfaces is 40 ft. per second; the temperature (by means of water cooling) is so controlled that it does not exceed 120 deg. F., and the temperature rise T is 25 deg. F. Required to assess r_E, μ, F, and Q.

Now the ratio $\frac{L}{W} = 0{\cdot}8$. Consequently from Graphs 2, 3, and 4, $\phi = 0{\cdot}083$, $k = 0{\cdot}7345$, $K = 8{\cdot}85$, and $C_E = 0{\cdot}0339$.

Then per (18) $r_{E\ (approx.)} = 0{\cdot}45 \times 0{\cdot}0339 \left(\frac{40 \times 350}{4}\right)^{\frac{1}{2}}$

$= 0{\cdot}903$ lbs. per sq. in.;

$$\mu\ (approx.) = \frac{r_E}{P_E} = \frac{0{\cdot}903}{350} = 0{\cdot}00258;$$

F (approx.), per (21) $= 0{\cdot}000819 \times 0{\cdot}0339 \times 40^{\frac{3}{2}}$

$\times\ 5\ (350 \times 4)^{\frac{1}{2}} = 1{\cdot}315$ horse power per pad;

Q (approx.), per (24) $= 0{\cdot}503 \times 1{\cdot}315$

$= 0{\cdot}662$ gallons per minute per pad.

* Letter in ENGINEERING, January 5, 1923, page 11.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN extra general meeting of the Institution of Mechanical Engineers was held on Friday last, the 6th inst., at Storey's-gate, London, the President, Mr. W. H. Patchell being in the chair.

ANTI-FRICTION BEARING APPLICATIONS.

The paper considered at this meeting was entitled "Anti-Friction Bearing Applications for Heavy Duty," by J. B. Dahlerus, of Luton. We commence to reprint this paper in abridged form on page 208 of this issue.

The President, in opening the discussion, said that one of his early experiences with roller bearings was in their application to 4-ton motor-generator armatures, and they found beneficial effect in starting. While running, there was little difference between a well-greased plain bearing and a roller bearing, but in the saving of starting current the latter were very effective.

Mr. David Bain said that about 1896 he had tried a set of roller bearings on a bogie carriage belonging to the North Eastern Railway Company. The arrangement consisted of ordinary cylindrical rollers which were fitted in a cage on the axle. After running for six or eight months on a local train between Leeds and Scarborough, it was found that the rollers were gradually getting out of alignment with the axle, and tended to lie across it. Then, due to the small area of contact between roller and axle, the rollers tended to pick up material out of the axle. Several tests of starting effort were made, and he believed there was a ratio of 5 or 6 : 1 in favour of the roller bearing. In the case of an underground service, where stops were very frequent, tramway services and the like, considerable advantage must result from the reduction in starting effort effected by the roller bearing. One disadvantage, so far as railway service was concerned, was that the roller bearing was more expensive to start with, and he did not at the moment see how the difference in cost was to be saved.

Mr. L. St. L. Pendred believed that it cost as much to start a train from rest as it did to run it for 50 miles, so that bearings of the class Mr. Dahlerus had described must prove useful in the case of short-distance trains. The Derby figures had been a revelation. Whether a vehicle was starting from rest, or moving steadily, far higher efficiency would be required in the case of plain than with ball bearings. He agreed as to the superiority of the Midland axle-box compared with that used on the Continent. One point in connection with ball bearings was the curious effect of "dry corrosion." Some years ago Mr. Macaulay had found that the inner sleeves, although run perfectly dry, or even if the shaft were constantly oiled, frequently corroded at a rapid rate. He had seen examples of this action between the tappets of motors on motor bicycles. He would be glad to hear from Mr. Dahlerus whether that mechanical difficulty still existed or not.

Mr. H. J. W. Oxlade remarked that in attempting to apply these bearings to the present railway axle a great difficulty arose at the outset in dealing with the shoulder collar on the end of the axle; much time was taken up over this as the presence of the collar rendered it impossible to fit a satisfactory roller bearing. Some railways had, however, discovered, after much trouble had been taken, that

they could do without this collar, but, generally, it had to be machined off, the journals ground for inner races and the collar replaced, or a nut substituted, with special provision, in some cases, in the new axle box for taking end thrust. All this work made the application of roller bearings somewhat expensive. He had had the advantage of discussing the subject with a railway man who preferred to dispense with this outside shoulder and, under exceptionally severe conditions, obtained results which proved the bearings were better without it. In the opinion of this engineer there was no good reason for it at all. Incidentally, he found him actually considering the use of a steel axle on a bogie with one wheel running free.

A short time ago there had been brought to his notice an axle of a somewhat revolutionary character for railway use, which was made up of three parts and might, in fact, be called a 3-piece axle. On looking into it he saw its possibilities from the roller bearings point of view; it got rid of almost all the difficulties and, with modifications, appeared to possess advantages not originally claimed for it. Speaking without particular knowledge of its possible application to railway vehicles, he would say that the properties generally considered desirable in a material to be used for an axle would be those which would withstand shock and fatigue, whilst the ends of the axle, where the bearing came, should be as hard as possible, and these requirements appeared to be well met by the new axle.

Roller bearings were, of course, very old, and he had been shown at the Stratford Works the design of a roller bearing in use on the Great Eastern Railway in 1860—the rollers, of course, being made in the wrong way, that was, too long, and the material not, of course, being so suitable as that now used—mounted on an axle journal without any inner race. His own experience of roller bearings did not come about until, unfortunately, he had to take charge of a motor car engaged in a week's reliability trial run between Delhi and Bombay, starting on Christmas Day in 1902. The experience was not fortunate. He had taken opportunities to look at a few patent specifications of axles, and incidentally he found that many people had been trying to get railway wheels to run independently like a free wheel. Quite a lot of patents had been taken out for axles with these wheels, and they were known to have been running on the Kalka-Simla Railway, and running satisfactorily. This opened out the possibility of further developments with roller bearings incorporated in the wheels.

Mr. Jenkins referred to Mr. Pendred's question about "dry erosion." A simple explanation existed, he thought. Was it not due to the structure of the material not being homogeneous? Comparatively little flow of the structure was set up in finishing operations. A good deal of flow was needed in the ordinary bearing to make the structure homogeneous; and there was then very little corrosion. With a slight difference of fit there would be alterations of surface stress, and contact was not continuous as the bearing was rotated, with a resulting tendency for the bearings to lose their burnished condition. Corrosion could then start, consequent upon exposure of the particles on the surfaces.

Mr. C. E. Davies said he had collaborated with the author in putting roller bearings in the rolls of cold-rolling mills, used mostly for rolling strip metal, steel, or brass. He believed greater advantage was derived from this application than from almost any other. This was probably due to the fact that 90 per cent. of the power taken by the mill was lost in bearing friction. A very serious difficulty was to keep the bearings cool; for this it was necessary to keep water running constantly on the bearings, quite preventing anything in the way of satisfactory lubrication. Roller bearings were especially important in view of the tendency towards increased rolling speed. In America the cold-rolling mills worked three or four times as fast as in this country, with increased difficulty in keeping bearings cool. The advantages he had anticipated from the use of roller bearings had been fully achieved. It was still difficult to foretell the life of roller bearings, but he believed that it would prove reasonably long. He would have no hesitation in recommending these bearings for finishing mills. The four great advantages were: (1) saving of power—proving to be from 30 per cent. to 40 per cent. at least; (2) heating of bearings practically eliminated; (3) rolled product more accurate; and (4) economy in lubricant. For new mills the increase in first cost would in part be offset by the fact that the gearing could be lighter and the driving motor smaller. The great objection was that the trunnions or roll necks had to be smaller, and he had anticipated difficulty in keeping the necks short enough to withstand severe loads. His firm had recently installed a 12-in. cold-rolling mill on the Continent working at 180 ft. per minute, in place of the usual 60 or 70 ft. Self-aligning was an important consideration; the roll had to bend, and unless the bearing could accommodate itself to that fact the load would come on the edge of the roll.

Mr. L. A. Legros referred to the early form of bearing mentioned by Mr. Bain. Roughly, he said, the roller proportions were $\frac{5}{8}$ in. diameter and $4\frac{1}{2}$ in. long, and the bearings were encased in a gun-metal cage. After running a little while the bearings got a little out of line. Tramway work was much more severe on the bearings than railway work. On the Waterloo and City Railway the same trouble had been experienced. It was a matter of pure chance what happened to the axle when alignment was lost. The rollers might cut it in at the neck and produce a failure. When failure began, in the last few miles the axle wore away quite rapidly; or the bearing would taper down at the outer end. Again, this effect would take place rapidly for the last four or five miles. He had not obtained a life of more than 10,000 miles out of any of those bearings. It was necessary to refer to the failures because a weak cage was one of the great sources of trouble in any bearing.

Mr. T. W. Cooper, who spoke next, observed that the author had stated that the roller bearing did not really come into extended use until 1916. The short cylindrical roller bearing introduced by the Hoffman Company was actually in use six or seven years earlier. The author had set out the characteristics which bearings should possess. With reference to their ability to deal with both radial and thrust loads and with thrust load in either direction, he felt that the dual loading on journal and axle introduced compound forces which had to be met by a component acting through one plane. Moreover, in connection with double-row bearings, by taking any load of magnitude one row of balls or rollers was thrown out of action. In whatever direction the thrust be taken the furthest opposite row of bearings had to take the whole load. With regard to self-alignment this might be an advantage in some cases, but was not essential. It was noteworthy that in Table 1 of the paper the coefficient of friction for the double-row self-aligning bearing was from 100 to 133 per cent. greater than that for the short cylindrical bearing. Recent tests at the National Physical Laboratory gave even better figures than those tabulated in Table 1, Col. 5.

He would be glad if the author could explain the difference between the Continental results and those of rolling stock in this country. He admitted that the anti-friction bearings saved on starting torque, but believed that the plain bearing was more efficient at the higher speeds, within certain limits. Wind resistance increased with the speed of trains, journal friction being then only a small proportion of the actual friction losses of the train. He felt that suburban lines might be considered as analogous to tramways, which had shown considerable saving by the use of anti-friction bearings. Referring to Table II, he would like to know why the resistance in pounds per ton was greater in the case of a train journey from Leicester to Kentish Town than when the reverse journey was made. Again, comparing Table III with Table VI, the former showed that the plain-bearing Midland train required 0·068 lb. of coal per ton-mile; in Table VI the comparative figure was 0·102 lb. per ton-mile, or considerably more. The respective consumptions of coal for the roller-bearing train were 0·07 lb. and 0·009 lb., or considerably less. He would have expected the same ratio. Under "Glasgow Tests," the author gave the percentage of saving of electrical energy in favour of the roller bearing as 11·62 per cent. The Wigan tests and L.C.C. figures, with the short cylindrical roller bearing, were 25·5 per cent. and 28·5 per cent. respectively; this illustrated again the higher saving value of the double-row bearing. A similar comparison could be made in the case of the resistance reduction figure, those obtained at Glasgow being 8·9 per cent., with no load, and 8·4 per cent. when loaded, while the L.C.C. tests gave 27 per cent. and 37 per cent. respectively. Finally, the author had spoken of oil for lubrication. Was oil advocated in preference to grease?

Mr. S. G. Williams drew attention to the importance of the material used in constructing bearings. The main requisite for successful roller bearings was improved steel, and this was now available. The older troubles were usually due to the material used. A steel of the type used to-day—high-carbon, high-chrome steel—was capable of withstanding the high compression loads experienced by roller bearings. Breakdown usually started with a small flat, due to crushing, which became progressively larger. On dismantling it was often found that pockets had been formed by the balls.

Mr. W. F. Cully asked the author if he would amplify his remarks regarding the manner in which the bearings failed. He wished to know if failure took place by wear or by fracture of the ball, roller, or the race. Further, was there any really logical known guide to impending disaster?

Captain H. Riall Sankey had an experience of long roller bearings in a three-cylinder Willans engine of the old type, used to drive a dynamo. The bearings worked well, but when the engine was dismantled flats were found on the rollers; they were so beautiful that they might have been machined.

Mr. D. B. Spittle declared that it had been thought that the "Michell" bearing could be adapted for roll work. An experiment made to determine if the film of oil would take a substantial share of the heavy pressure coning on the neck did not prove informative. Pads were inserted in order to adapt the Michell principle to a cylindrical bearing for rolls, but also without much success. The great difficulty seemed to be to get such a circulation of oil as would permit of the principle of the film of oil taking the pressure applying.

Mr. J. B. Dahlerus, in reply, referred firstly to the discouraging effect of the bad experience with roller bearings in the early days. He thought that as regards railway work, no better indication could be given than the number of hot axle boxes per thousand axle boxes running during a year. Among railway companies, both in Europe and in the United States, whence statistics had been obtained, there were no results which approached those of the Midland Railway; it was that which had led to the request made to the Midland Railway Company to carry out tests with modern anti-friction bearings. An important factor to be considered, affecting the results of the tests, was the variation in the weight of the trains. In the case of the Midland Railway, the weight per coach would be about 30 tons or per axle box about $3\frac{1}{2}$ tons. The coaches running in America and on the Continent generally carried about 60 tons per eight boxes. Therefore the conditions were very different. In reply to Mr. Pendred, it was difficult to give a general reply as to cost of starting. In one instance, a railway company equipped all their coaches with roller bearings. The line was a fairly level one and the maximum effort to be made by the engine was in starting up the train. The engine could take twelve coaches, but, for various reasons, 15 were wanted, necessitating a change over of the type of engine to a heavier and more powerful class. This would have meant re-building seven bridges along the line. By equipping their rolling stock with anti-friction bearings, however, it was found that the existing type of engine could be preserved, and, of course, no rebuilding of the bridges was necessary. The Pennsylvania Railroad had been running some of their 60-ton coaches on eight-axle boxes for

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Fig. 79.

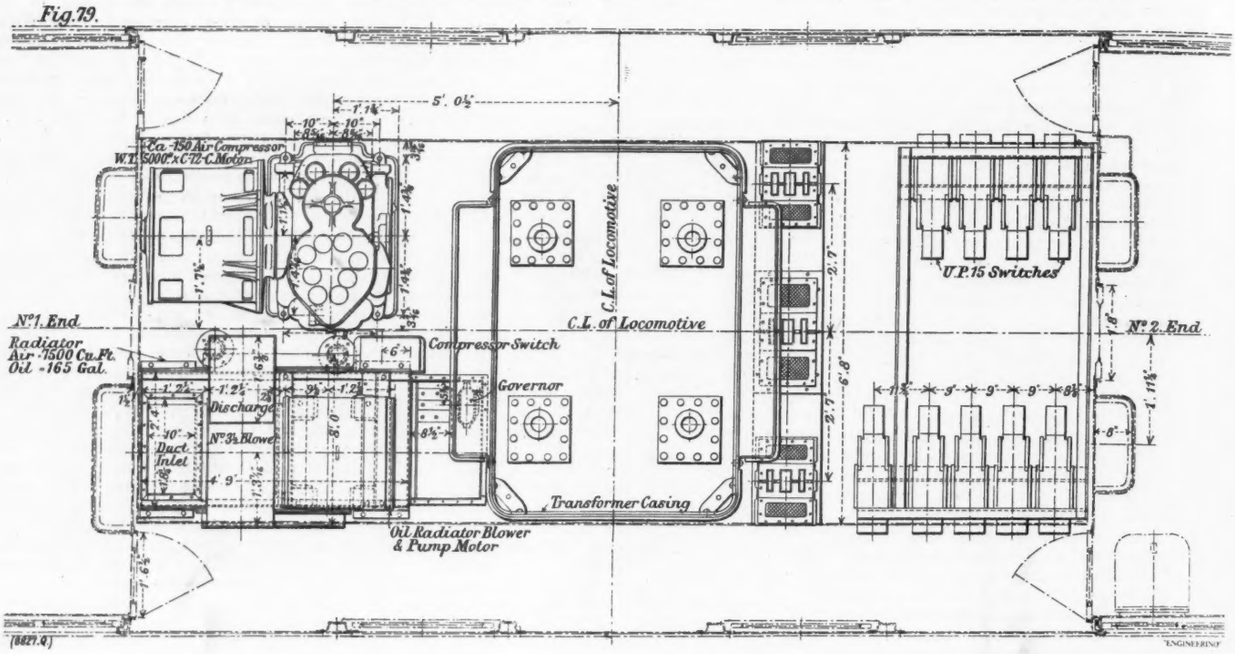


Fig. 80.

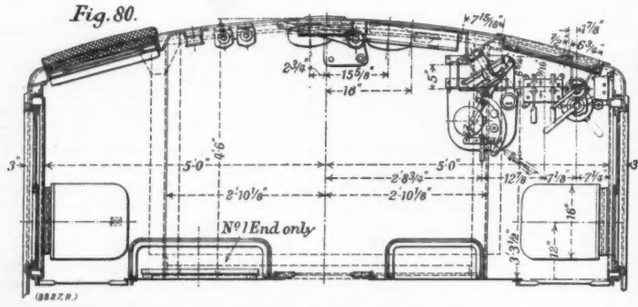
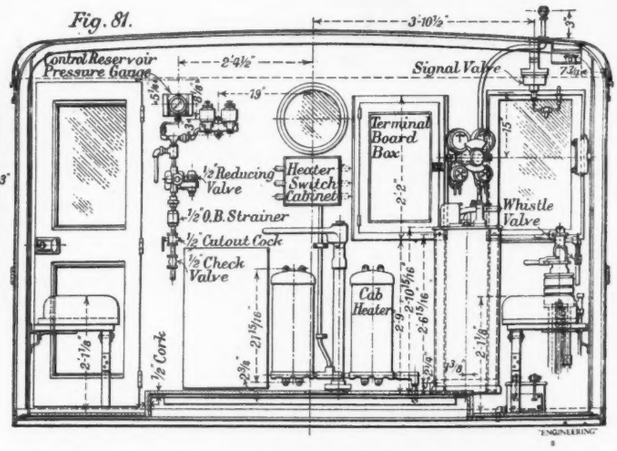


Fig. 81.



more than three years and had covered more than 300,000 miles per coach. The object of fitting the axle boxes was not to save power, but to overcome the trouble they had experienced with hot boxes. They had no trouble with the coaches that had been fitted with roller bearings. Consequently they had applied these bearings to their coaches on a large scale. Where, as in railway or aeroplane practice, the breakdown of anti-friction bearings might mean the loss of many lives, it was obviously necessary to be certain that not only workmanship, but the material, was right.

The President then announced that there would be an informal meeting to-night at 7 p.m. The subject for discussion being "Gear Production Machinery." The annual general meeting would be held on Friday next, the 20th inst., at 6 p.m., when the annual report and the election of council would be taken, followed by the resumed discussion of Mr. Dahlerus' paper.

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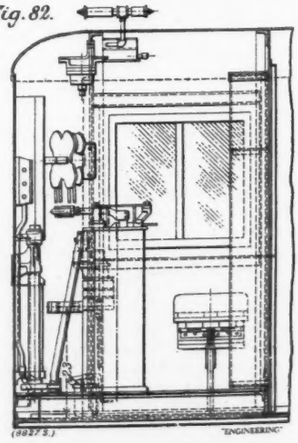
(*Concluded from page* 128.)

Having dealt with the general lay-out, main frame, trucks, suspension system, and braking arrangements of the locomotives, we may now turn to some of their electrical features. It is not intended or supposed, however, that all components of these or any other electric locomotives can be specifically labelled mechanical or electrical, and the motor and jackshaft drive to which we wish first to refer is clearly as much one as the other. The drive is illustrated in Figs. 55 to 62 on Plates XI and XII, the general views forming Figs. 55 and 56 in particular giving an excellent idea of the very substantial nature of this feature of these remarkable machines. As has already been stated in the earlier part of our description, and as is clearly shown in Figs. 55 and 56, two motors are mounted side by side at each end of the locomotives, and drive a common jackshaft through gearing. As already stated, identical motors are used throughout to three locomotives which have been built. They operate on either direct or alternating current. The motors run at approximately 580 r.p.m. for maximum locomotive speed, and the different speed characteristics for freight and passenger service, with respective maximum speeds of 35 and 70 m.p.h., are obtained by alterations to the gear ratio. Figs. 55 and 56 show the alternating-current locomotive with passenger-service gears.

Fig. 82.



The motors, of which the detail arrangements are well shown in Figs. 57 and 58 on Plate XII, are of the series commutator type with an auxiliary field and commutating field in series with the main field winding. The main purpose of the auxiliary field is to improve the power factor of the motor by neutralising the magnetisation of the armature, and the purpose of the interpole field is to assist

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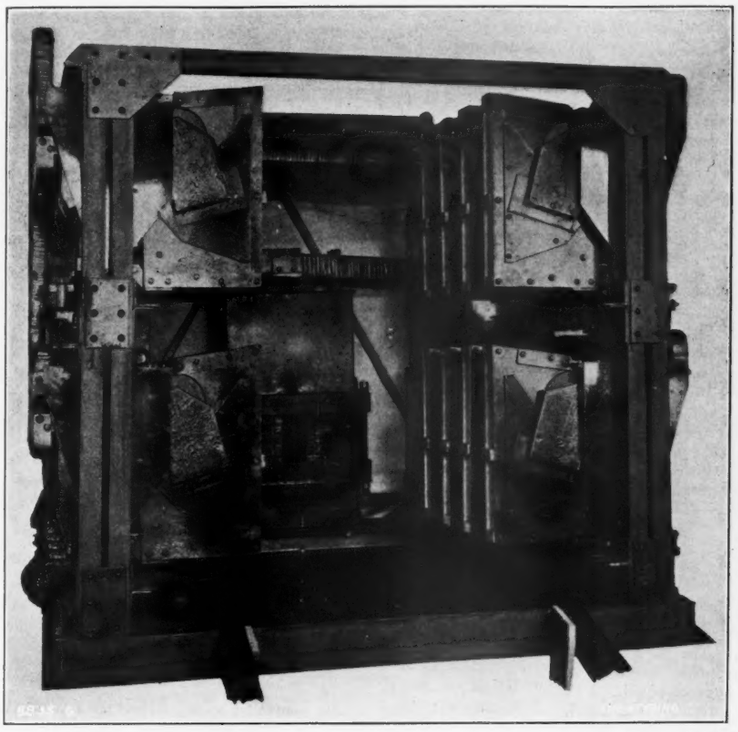

FIG. 83. ASSEMBLY OF UNIT SWITCHES IN FRAME.

FIG. 84. UNIT SWITCH.

commutation by producing a neutralisation of the field in the armature coils at the time when the commutator bars to which they are connected are under the bushes. Each motor has a one-hour rating with forced ventilation of 815 h.p., and a continuous rating with forced ventilation of 760 h.p., giving locomotive ratings of 3,260 h.p. for one hour, and 3,040 h.p. continuously. All these ratings are at the rim of the wheel. Various details of the motor will be gathered from Fig. 57, from which it will be seen that the commutator is 5 ft. in diameter. The outside diameter of the motor frame is 6 ft. 4 in., and it is 3 ft. 7¾ in. long.

The motor frame is bolted directly to the locomotive end frame, which is formed to accommodate it. The arrangement is indicated by Figs. 55 and 56, but will best be followed from the drawings of one of the end frames, forming Figs. 2 and 3 on Plate VII, which accompanied the first part of our description of these locomotives in our issue of January 30. The arrangement results in the motor frame becoming for all practical purposes an integral part of the locomotive main frame. The motor bearings, which are 9 in. diameter, are quite separate from the motor frame, but are carried by the locomotive side frame, as shown in Fig. 57. Details of the motor bearings are given in Figs. 63 to 68. The arrangement of the jackshaft bearings is clearly shown in Fig. 58. Each is made in the form of a circular shell which is a press fit into the end cradle, and is fitted with phosphor-bronze inserts and babbitt wearing surface. The detail arrangement of the gears will be followed from Figs. 56 to 62. The gear wheels are of a flexible type in order to provide an elastic coupling between the motor armatures and the running gear. Before referring to the details of these gears, however, reference should be made to either Fig. 1 or Fig. 52 of the earlier section of this description. Both of these figures gave general views of the completed locomotive, and it will be clear from either of them that the projection of the end nuts securing the pinion on the motor shaft has, in the case of the two inner motors, to be kept small enough not to foul the side rods. The same point does not arise in connection with the outer motors, and advantage has been taken of the greater freedom allowable by the introduction of a modified pinion.

Turning now to Fig. 57, it will be seen that pinions of different diameter are shown on the left-hand side of the view and on the right-hand side, and that two pinion arrangements for each diameter are indicated. The left-hand gearing is that employed for the high-speed passenger locomotive and corresponds with that shown in Figs. 55 and 56, while the right-hand gearing with a smaller pinion shows the arrangement used for the freight locomotive. In each case the pinion for the inner motor is made solid, as the end space available does not allow of a flexible pinion being fitted. These solid pinions are shown as independent views outside the general view at each side of Fig. 57. The flexible pinions for the outside motors are shown in position on the motor shaft. Their arrangement will probably best be followed if we refer first to the details of the flexible spur wheels which are shown in Figs. 59 to 62. These wheels are built up from cast-steel centres carrying forged steel gear rims. The rims can ride on the centres over a short travel which is limited by sunk keys. The drive from the rim to the centre is taken by nests of leaf springs, which are inserted in pockets, without any initial tension. They are retained in position by locking springs, which are clearly shown in the detail given in Figs. 61 and 62. As shown in the former of these two figures and in Fig. 59, the leaf springs engage slots in the outer rim to transmit to drive. From this description of the flexible gear wheel, the arrangement of the outer flexible pinions will be easily followed from Fig. 57. As will be seen from the pinion on the left-hand side of that figure, the larger pinion which is used for the locomotive with the passenger service gear ratio, is formed in much the same manner as the spur wheel, and the arrangement will be understood from the figure without further reference. In the case of the smaller pinion, however, shown on the right-hand side of the figure, the radial space available is insufficient for a corresponding arrangement of the leaf spring and a modification has had to be adopted. The boss of the pinion in this case is divided into two parts. The inner part is secured to the motor shaft by a key and taper and the pinion rim works on a sleeve on the outside of it. An extension of the inner part of the boss carries a series of leaf springs, and these springs drive the pinion rim through an outer flange. Though not in the actual plane of the gears, the effect of the arrangement is a flexible drive between the shaft and the pinion teeth, corresponding in every way mechanically with the more direct and simpler arrangement of the larger pinion shown on the left-hand side of the figure.

The motors are supplied with current from an oil-immersed forced-cooled transformer which is mounted on the frame of the locomotive approximately in the centre. This transformer with its radiator and blower is shown in the general view given in Fig. 77 on Plate XIII. As the point has been raised in connection with the mounting of this transformer, we should say that all heavy apparatus is supported directly from the frame in this way, and not through any part of the cab, which is a light structure designed as a protection against the weather only. Previous to the construction of this locomotive, it had been the practice of the Pennsylvania Railroad to use a forced air-cooled transformer on their alternating current machines. With such constructions, however, great difficulty has been found in so cleaning the air that coal dust, dirt and soot should not be carried to the interior of the transformer. This particular difficulty is accentuated on a locomotive where the area from which the air must be taken is necessarily small, and the difficulty of installing a cleaning device of sufficient area to take care of the large quantities of air used, is very great. To eliminate these difficulties an oil-insulated transformer was decided on for the locomotives with which we are concerned, and, to

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Fig. 85.

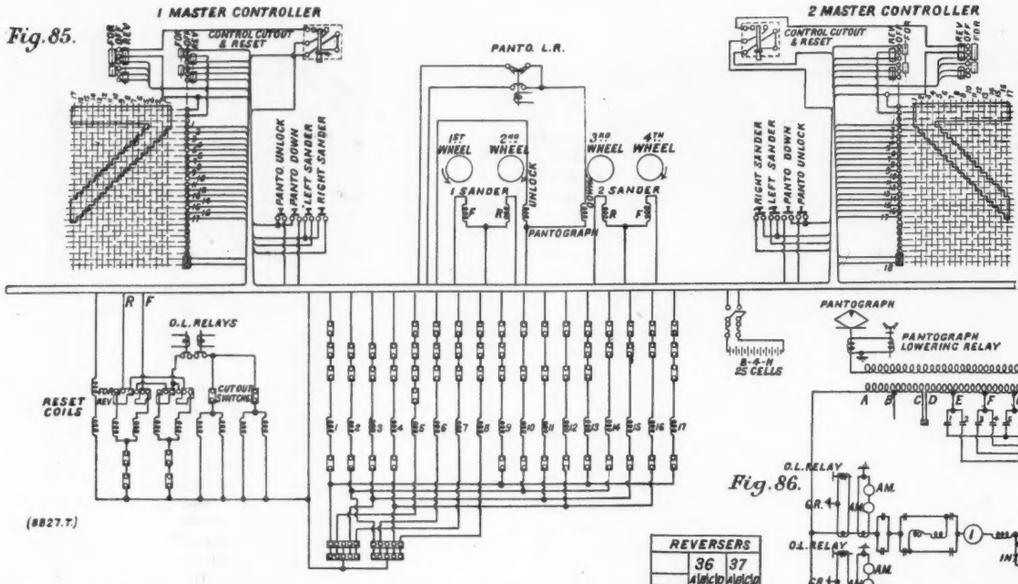
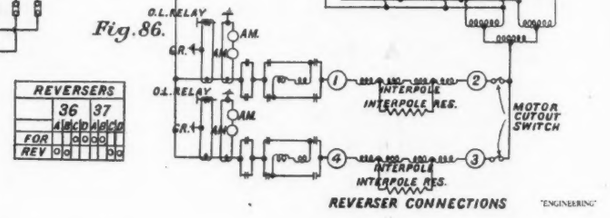


Fig. 86.



reduce the weight of this oil-cooled transformer to the lowest limit possible, it was decided to circulate and cool the insulating oil through an outside forced-cooled radiator. The plant illustrated in Fig. 77, to which we have already referred, has been installed for this service. The motor, blower, pump and radiator are shown independently in Figs. 72 and 73, on Plate XII, and in Fig. 74 on Plate XIII. The pump continually draws the oil from the transformer and circulates it through the radiator which is kept cool by the air drawn through by the blower. The arrangement approximates to the light weight of an air-blast transformer and retains the reliability of an oil-cooled, oil-insulated transformer. It will be clear from Figs. 72 and 73 that the oil pump and blower runner are attached to a common armature shaft. The air for the radiator is drawn in from the bottom of the cab, and discharged through a ventilator in the cab roof. A plan showing the arrangement of this apparatus and the transformer in the cab is given in Fig. 79 on page 186.

Current is taken direct to this main transformer from the pantograph at 11,000 volts, without passing through any protective device such as an oil switch. This is indicated in the diagram of main connections given in the lower right-hand corner of Fig. 85 on this page. As shown in this figure there is, however, a pantograph lowering relay incorporated in the system. This device, which serves to protect the high-tension circuits on the locomotive, has been used successfully for several years by the Pennsylvania Railroad, on their multiple-unit cars. The arrangement is such that when a ground or short circuit occurs on the winding of the transformer, the excessive current passing causes a series transformer to operate an overload relay. The relay establishes the initial connection in the circuit to lower the pantograph, but does not complete the circuit. Owing, however, to the excessive current passing to ground, or to the short circuit, the oil circuit-breakers in the nearest substation, which is feeding the trolley wire, open. The effect of this cutting off of current from the line is that the no-voltage relay on the locomotive completes the pantograph lowering circuit, and lowers the pantograph at a time when there is no current on the line, thus isolating the locomotive.

The main low-tension circuits of the locomotive are indicated in the diagram of connections reproduced in Fig. 86 on this page. From the low-tension windings of the transformer taps are taken and connection made to the motors through preventive coils and electro-pneumatically operated unit switches. The purpose of the preventive coils is to permit a change of voltage on the motors by changing the taps to which they are connected on the transformer without either opening the circuit of the motors, or short-circuiting the windings of the transformer. With the arrangement provided it is possible to utilise any position of the controller, except the first three, as an operating position, and in this way secure a practically uniform speed control variation from zero to full speed, while at the same time permitting any intermediate point between these two positions to be utilised as a running or operating position. The unit switches and preventive coils are mounted directly on the locomotive frame in the manner already mentioned. Their arrangement is shown in the plan of the centre portion of the locomotive given in Fig. 79 on page 186, while they can also be seen in the view given in Fig. 77 on Plate XIII which has already been referred to. A closer view showing the unit switches and preventive coils only before assembly on the locomotive is given in Fig. 78 on the same plate. This view clearly shows the main low-tension strap connections. The unit switches assembled in a frame preparatory to mounting in the locomotive are shown in Fig. 83 on page 187, while Fig. 84 on the same page shows a front view of one of the same switches. This view clearly shows the interlock fingers and the main contacts. There are in all 17 unit switches on the locomotive frames inside the cab. They are of heavy current-carrying capacity, and are provided with magnetic blow-outs and auxiliary contacts. There are two similar unit switches on the locomotive frames under the motor hoods at each end of the locomotive. These, however, come into operation only in case of motor overload.

The control circuits of the locomotive are shown in the main diagram of Fig. 85. The control of the motors is effected by the operation of one or other of two master controllers, one of which is located in each of two motorman's compartments at either end of the main cab. The controllers are indicated in Fig. 85, while the arrangement of one of the motorman's compartments is shown in Figs. 80 to 82 on page 186. The movement of the master controller causes the operation of the electro-pneumatic unit switches from a 25-cell control-storage battery, which is indicated in Fig. 85. By moving the master controller to the desired position, the motorman can apply any desired voltage to the main motors, and so regulate the motor current and speed of the locomotive. Under the hood at either end, and mounted on the locomotive frame, is an electro-pneumatically operated reversing switch, which governs the direction of rotation of the motors under the control of the motorman. These reversers are indicated in Fig. 86, and two views of one of them are given in Figs. 75 and 76 of Plate XIII. Other apparatus in the motorman's compartment comprises the necessary brake valves, sander pedals, pantograph raising and lowering buttons, and indicating ammeters to permit the motorman properly to control the operation of the locomotive and the train. The positions of these various pieces of apparatus are indicated in Figs. 80 to 82.

In addition to the apparatus we have already mentioned, the main cab contains a motor-driven air compressor for the brake service and for other air-operated apparatus. This is indicated in the plan given in Fig. 79. The set is a slow-speed unit operated by a single-phase commutator-type motor through worm-reduction gearing. The set has a capacity of 150 cub. ft. of free air per minute. A further piece of auxiliary apparatus forming part of the equipment of the locomotive is a small motor-generator set for charging the control-circuit battery. This battery also serves the lighting circuits. There is also an auxiliary motor in connection with each pair of main traction motors. Each of these drives two blowers, which draw air through the motors instead of forcing it through, as is the more usual practice. The motors are identical with that fitted in connection with the cooling arrangements of the main transformer, the only difference being that the motor shaft carries blower runners at each end, instead of a blower runner and a pump, as is the arrangement with the transformer set. These motor ventilating auxiliaries with their ducts are clearly shown in position above the motors in Figs. 57 and 58 on Plate XII. In connection with Fig. 79 of page 186, we have already mentioned that all heavy apparatus is mounted directly on the locomotive frame and that the cab forms a weather protection only. It should, however, be said that this structure is so arranged that it can be easily detached and lifted off the locomotive, so facilitating

access to any part of the main equipment. It is also possible readily to remove any part of the roof to enable any piece of equipment to be lifted out.

As has been made clear several times in the course of this description, the direct-current locomotives in their mechanical features and motors follow the alternating-current machines which we have described. As, however, they operate on a 650-volt third-rail system, the current-collecting arrangements are, of course, different. The details of the third-rail shoe used, are given in Figs. 69 to 71 on Plate XII. The arrangement covered by these figures will be easily followed from them without comment. The direct-current locomotives are, of course, equipped with suitable control gear. The motors are permanently connected two in series, and the two pairs are then connected for series-parallel control on the lines of standard practice for two-motor equipments for inter-urban railway work. The motors are also provided with field shunts for the purpose of giving additional running or operating positions of the controller. The necessary main-resistance frames are mounted in the cab. The electrical equipments for both classes of locomotive were supplied by the Westinghouse Electric and Manufacturing Company of East Pittsburg. As we mentioned at the beginning of this description, we are indebted to Mr. J. T. Wallis, Chief of Motive Power of the Pennsylvania Railroad System, for information and drawings on which our description of these interesting machines is based.

LITERATURE.

Factory Lay-Out, Planning and Progress. By W. J. HISCOX. London: Sir Isaac Pitman and Sons, Ltd. 1924. [Price 7*s.* 6*d.* net.]

THERE is no doubt that the need for efficient and systematic planning is being increasingly recognised; there is no doubt either that, in the absence of efficient planning, the time taken for the manufacture of any given unit will be greater than it ought to be, such a condition being accompanied by an abnormal amount of work in progress, which, of course, means idle capital. In Mr. Hiscox's book the subjects both of planning and progress are treated. There is much that is good in it, although it appears to be more discursive than it need be. It is divided into two parts, one dealing with planning and routeing, the other with progress work. In the first part there are chapters on "Shop Lay-out for a Standardised Product"—Allotment of Duties (Executive), Production Planning, and Routeing Systems and Control Boards. In the second part, progressing for different departments and circumstances is described and examples of progress reports are given. While the author states that "the scheme is unfolded in a non-technical manner," in which he has certainly been successful, we could wish that in some instances the treatment had been less elementary, and, in others, that a broader outlook had been taken. The importance of the planner rather than that of planning appears to be deeply rooted in the author's mind.

He states "that planning is a comparatively modern institution," and infers that without a planner efficient manufacturing arrangements are not likely to be made: "We find that the advent of the planner coincides with the establishment of a bonus system, and that his activities are limited to the standardising of operations and rates. He may, in some instances, effect reforms in the lay-out of the plant for the purpose of facilitating production, by re-grouping machines, devising more up-to-date accessories and superseding certain units by more modern appliances. He may institute a more efficient method of transport, revolutionise by means of operation-planning the grade of labour, and exploit the advantages he has created by means of co-ordination in the matter of routine. These reforms are undoubtedly valuable, and entitle the management to boast of their well-organised factory, but the scope of the planner is limited, nevertheless. He works upon what is already in existence—the construction of the factory, its floor area, the design of the product, and the policy of the directors, as exemplified by the system prevailing.

"He cannot raze the building to the ground and erect another to his own specification, neither can he remove the factory to a more satisfactory site."

Such an attitude is not necessarily justified, although it is not infrequently taken up when persons rather than functions are discussed. There are factories which have been most efficiently planned, both in plant and production, where the "planner" is unknown; alternatively, in some factories where the planner has been let loose, production has been found to be deplorably badly handled. This is true, without detracting at all from the value of planning. There is a tendency to-day to look upon some of these "new" functions as indicating that heaven-born genius has, providentially, come to the rescue of industry. Actually, planning is the response made by industry to meet the altered conditions which are the result of competition and subsequent specialisation. After all, the work of planning is not new, although the name may be. Factories and production have always been planned, the latter usually by the shop foreman. This has been well or badly done, accordingly as he has had control of the manufacture of the complete article or not, the results reflecting his ability on the one hand, and the extent by which he was overburdened with duties on the other. Specialisation has tended to bring about the decentralisation of plant and manufacture, this reacting on the opportunity—not the ability—of the foreman to plan effectively. Planning being as necessary under the new as under the old conditions, if the amount of work in progress is to be kept down to the minimum—the ultimate object of planning, although not always recognised—it follows that planning must be done by an official who can take the same broad view as did, previously, the foreman, when controlling the manufacture of the complete article.

These are the conditions and the duties which call for the planner. It will be dependent upon the knowledge of the person appointed to do this work as to whether it will be well or badly done; as to whether he will be an efficient, as well as a "severe critic of design," or not; as to whether he should control or be controlled by the rate-fixer. The author's remarks on "rate-setting" are peculiarly unhelpful, and in stating that the rate-setter must know "the capabilities of the operator" he is suggesting a policy which has been at the bottom of most of the trouble experienced with payment by results. The wisdom of giving the planner the control of tool design and manufacture is open to question. The reshuffling of responsibilities will usually show some advantages, but these are invariably accompanied by some counterbalancing objections. Some firms have found that to have tool design and manufacture under the same control is almost as unsatisfactory as Mr. Hiscox thinks the influence of the designer of the product is on its economical production. The book covers 184 pages of easily read type and is interspersed with many diagrams and charts.

The Principles of Applied Electrochemistry. By A. J. ALLMAND, D.Sc., F.I.C., Professor of Chemistry, King's College, London. Second edition, revised and enlarged by the Author and H. J. T. ELLINGHAM, B.Sc., Lecturer in Physical Chemistry, Imperial College of Science and Technology. London: Edward Arnold and Company. [Price 35*s.* net.]

IN introducing the second edition of his Applied Electrochemistry, Dr. Allmand remarks that, the elements of physical chemistry now being more generally appreciated in technical circles, he has omitted the chapters on equilibrium and osmosis of his first edition of 1912, and has re-written the first general and theoretical part, while enlarging the second applied part. The volume has indeed grown from 586 to 726 pages. "The twelve years under notice comprised the war period during which electrochemical and electrometallurgical methods more than maintained their ground in the enormous industrial expansion which then took place." Dr. Allmand rightly speaks of expansion. One can hardly refer to large development. In few branches of applied science has there been so little development during the last decade as in electrochemistry. We might say that electrochemistry has not fulfilled the predictions of a great future made at the close of the last century. But it is perhaps more correct to put it differently. Electric energy and electric devices are the general handmaids of applied science, theoretical chemistry is more and more becoming a branch of physics, and electrochemistry stands less apart than it was thought to do. Electrometallurgy is largely electrothermics; the chemist varies electric potential as he varies pressure and temperature in his operations; but as regards electrode reactions in applied electrochemistry Dr. Allmand and Mr. Ellingham have little advance to record.

The second edition opens like the first with sections, which should be less brief, on chemical and electrochemical methods, electric units and power, and passes on to Faraday's law, dissociation, electromotive force, energy relations, electrolysis and polarisation and electrode reactions, making in this last section frequent reference to Foerster's electrochemistry of aqueous solutions. Sections on molten electrolysis, electrothermics, and discharge of gases, conclude the first part which takes up a third of the volume. The second, special and applied part, begins with primary and secondary cells. Dry cells are dismissed in less than two pages, and recent reports on their performance are not noticed, while fuel cells, which even the latest researches of Baur hardly bring near applied science, receive full consideration, as do the alkaline nickel-iron cells, which we should not simply style "iron or Edison accumulators." The following sections deal with copper, silver, gold, and with zinc, lead, tin, nickel, iron and miscellaneous metals, the treatment being, for instance, copper refining in theory and practice and then copper extraction. The next chapter on electroplating and electrotyping looks a little forelorn after this, and one would hardly expect to find Elmore copper-tube process at the very end of this chapter. There is no section on electrolytic corrosion.

After hypochlorites and chlorates, alkali-chlorine cells and other electrolytic processes of aqueous solution and fused salts, we come to electric smelting in the iron and steel industry, including ferro-alloys, and a further chapter on electric refining, melting and heat treatment of steel. This subdivision is uncommon; in the first edition the whole subject was discussed in one chapter, and we cannot see that anything is gained by either this division, or by the retainment of the general arrangement above outlined, which, for instance, places the historically older and simpler copper-plating after the newer and more complex copper refining and extraction. Again we find graphite following calcium carbide, cyanides and carborundum. The one page on fused silica is disappointing, and does not mention the Helberger vacuum-compression furnaces which have long since yielded a clear nitreous silica; nor are the American high-frequency induction furnaces noticed. The authors themselves regret to have had to exclude endosmosis and kataphoresis and electric fume precipitation; if it were a question of space, the authors might have sacrificed the electrothermal treatment of steel, which is a big subject in itself. That there was little to add as regards organic chemistry is not their fault. In general they have certainly taken pains to bring the matter thoroughly up-to-date; their appreciation of relative importance might be questioned. With complete rewriting phrases like "voltage is measured by voltmeters," might well have disappeared. The two very complete indexes, in which this time the initials of names are given where desirable, will help the volume to retain its high position.

THE SOUTH WALES COAL ANNUAL, 1925.—In a country such as our own, any available means calculated to bring foreign buyers into touch with producers are to be welcomed. The twenty-first edition of The South Wales Coal Annual, dated 1925, and published by The Business Statistics Company, Limited, of Baltic House, Cardiff, at a price of 12*s.* 6*d.* net, is intended to assist in this. The work provides a wealth of information on the various aspects of the Welsh coal trade. Wages, prices, exports and freights are recorded, together with tables giving the production of the chief countries of the world for the past ten years. Further statistics on anthracite, patent fuels, coke, costs, and profits of coal mining, are included, while an elaborate index at the beginning of the book greatly increases its value as a work of reference.

THE FORD ELECTRICAL TORSIONMETER.

CONSTRUCTED BY MESSRS. SIEMENS BROTHERS AND CO., LIMITED, ENGINEERS, WOOLWICH.

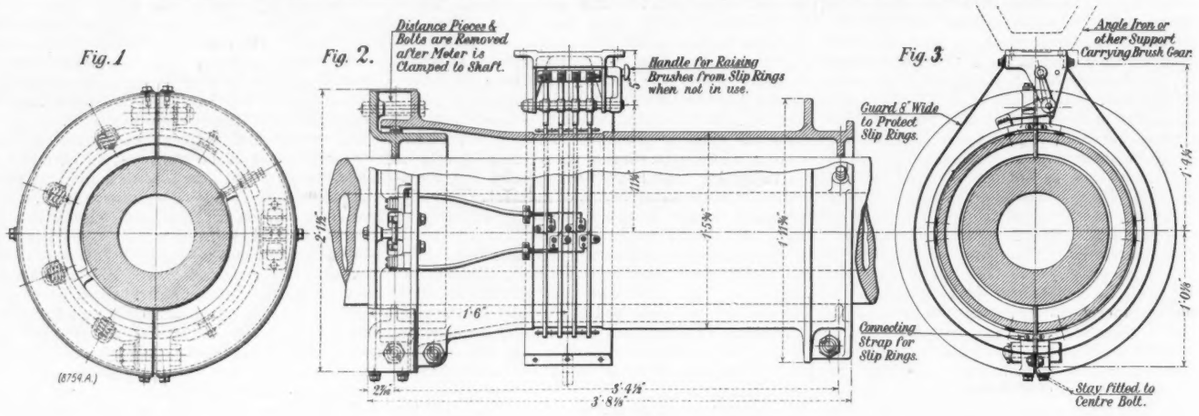


Fig. 1
Fig. 2.
Distance Pieces & Bolts are Removed after Meter is Clamped to Shaft.
Handle for Raising Brushes from Slip Rings when not in use.
Guard 5" Wide to Protect Slip Rings.
Fig. 3.
Angle Iron or other Support Carrying Brush Gear.
Connecting Strap for Slip Rings.
Stay Fitted to Centre Bolt.
(8754 A.)

THE FORD TORSIONMETER.

THE figures on this and the opposite pages illustrate a new form of electrically-operated torsionmeter constructed by Messrs. Siemens Brothers and Co., Limited, of Woolwich, London, S.E.18, who, as the manufacturers, for many years, of the Hopkinson-Thring torsionmeter, have had extensive experience in the construction of instruments of this class. The new torsionmeter, which is made under the patents of Mr. J. M. Ford, includes many features of considerable interest, as will be apparent from the description which we give below. We may first mention, however, that it has been designed to indicate the mean torque on a shaft, and can, therefore, be used for determining the horse-power of steam or internal-combustion engines, with which the torque varies during the course of a single revolution, as well as with steam turbines, which give a uniform torque. For investigating the working of reciprocating engines, however, it is a comparatively simple matter to arrange the instrument to give readings of the torque at any point of a revolution. The instrument, as described, is intended to measure the mean torque only, this being the usual requirement for a commercial installation.

The Ford torsionmeter comprises two main parts, one consisting of a collar and sleeve, fitted on to the shaft in the usual manner, and the other being an indicating unit which can be mounted in any convenient position and at any distance from the shaft. Figs. 1, 2 and 3, on this page, show the general arrangement of the shaft unit, a photograph of which is reproduced in Fig. 4, while the appearance of the indicating unit is illustrated in Figs. 5 and 6, the cover being removed in the latter to show the interior. The casing of the indicating unit is made watertight. The electrical connections are shown in Fig. 7, but before referring to this diagram, it should first be explained that the principle involved depends upon the fact that any variation in the length of an air gap in the iron core of a transformer, by altering the value of the magnetic flux, will cause a corresponding variation in the electromotive force induced in the secondary winding. In the Ford torsionmeter, the air gaps of a differential transformer are altered by the relative movement between the sleeve and collar fitted on to the shaft which results from the torque on the latter, and at first sight it might be thought sufficient merely to measure the secondary E.M.F. in order to determine the magnitude of the torque. Further consideration will show, however, that such readings would be liable to serious errors arising from variations in the primary E.M.F., in the ohmic resistances of the windings and other parts of the circuits, in the calibration of the measuring instruments, and other factors, so that they would be of but little value.

These errors are avoided in the instrument under consideration by employing the null method of measurement. Two exactly similar transformers, one having air gaps varied by the torque and the other having gaps adjustable by hand, are used, the primary windings of both being connected in series, and the secondary windings being arranged so that the induced E.M.Fs. oppose each other. It, therefore, follows that when the air gaps of the two transformers are made equal, no current will flow in the secondary circuit. A centre-zero instrument is included in the secondary circuit to indicate when this condition has been reached, and if the adjustable gaps are varied until a balance has been

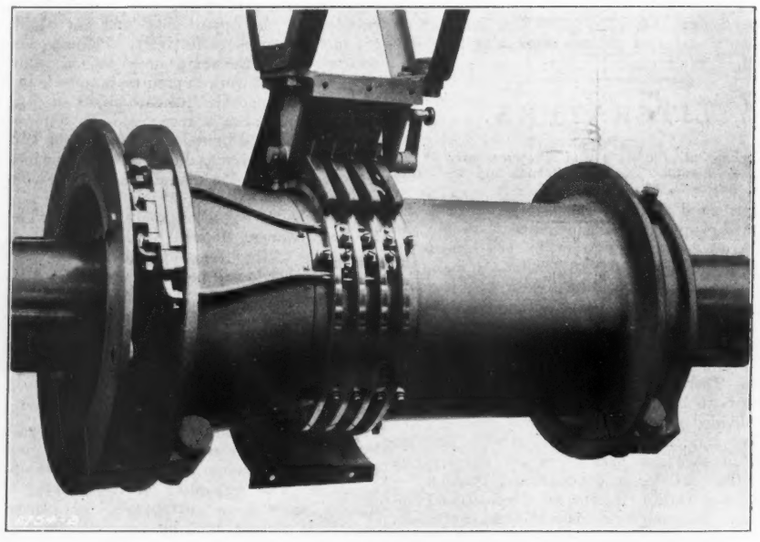


FIG. 4.

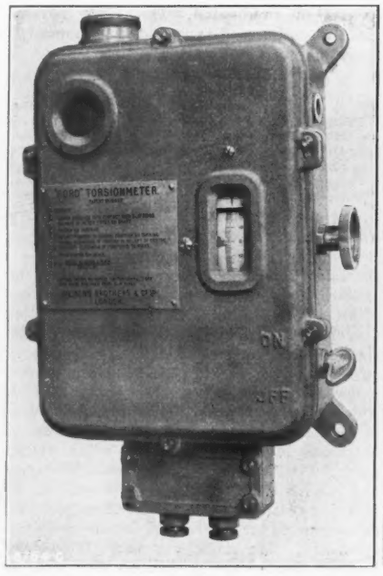


FIG. 5.

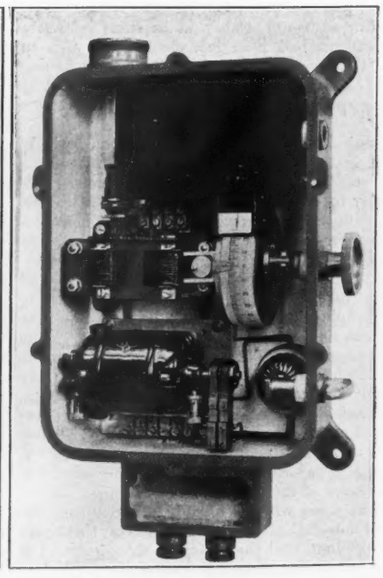


FIG. 6.

THE FORD ELECTRICAL TORSIONMETER.

CONSTRUCTED BY MESSRS. SIEMENS BROTHERS AND CO., LIMITED, ENGINEERS, WOOLWICH.

Fig. 7.

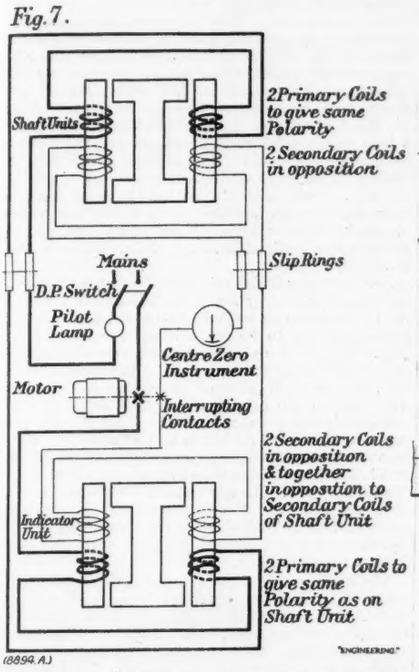


Fig. 8.

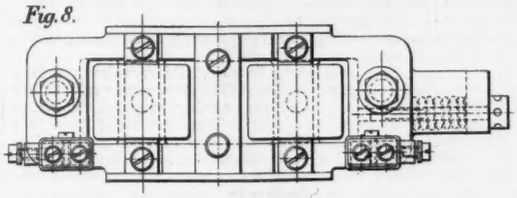


Fig. 9.

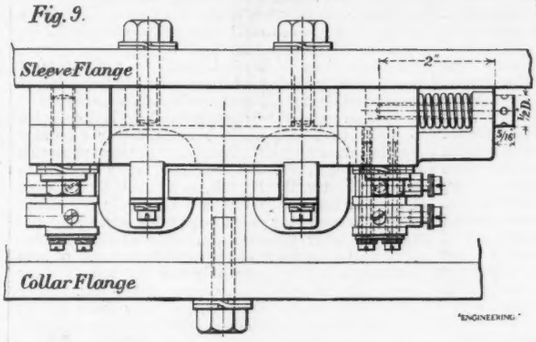


Fig. 10.

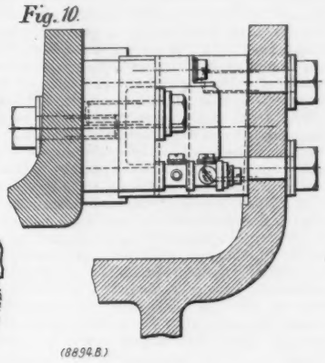


Fig. 11.

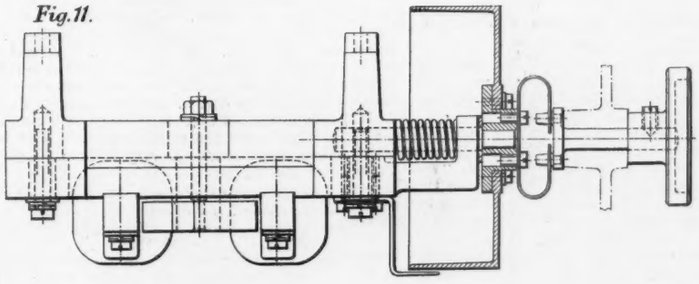
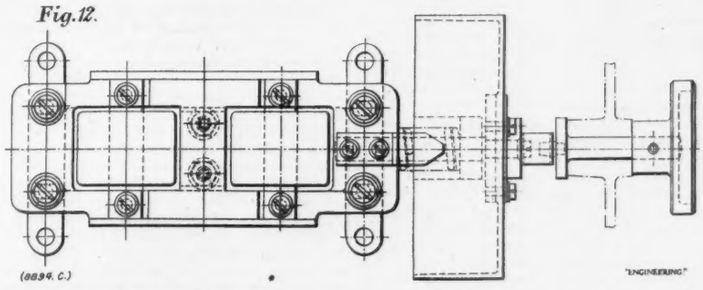


Fig. 12.



obtained, the movement necessary to effect the balance is a measure of the torque on the shaft. This instrument can be seen in Fig. 6.

The actual arrangement of the apparatus is illustrated diagrammatically in Fig. 7. In this illustration, the upper transformer is that of which the air gaps are varied by the torque, the lower one being arranged so that its air gaps are adjustable by hand. The former, which we may refer to as the torque transformer, is shown in detail in Figs. 8, 9 and 10. It consists of two laminated iron cores, each carrying primary and secondary windings and mounted on a flange of the sleeve. Slip rings on the latter, clearly shown in Figs. 2 and 4, enable the electrical connections with the windings to be made by means of carbon brushes, but owing to the fact that a null method of measurement is employed, variations in the contact resistances at this point in the circuit do not affect the results. The shaft collar carries an H-shaped laminated iron core, or armature, which fits between the two cores above referred to, leaving small gaps about $\frac{1}{16}$ in. in length on each side as indicated in the diagram, Fig. 7.

With this arrangement, it will be readily understood that the relative movement of the sleeve and collar, arising from any torque on the shaft, will shorten the gaps on one side of the transformer and open out those on the other side. The movement it may be mentioned, amounts to about 0·025 in. as the load on the shaft increases from zero to the full normal value.

The primary windings are supplied with an interrupted direct-current obtained from the ship's mains, a contact breaker driven by a small electric motor, shown in Fig. 6, being used to interrupt the current. Eccentric fibre discs, mounted directly on the motor spindle, are used to operate the contact breakers, as will be understood on reference to Fig. 6. The power taken from the mains for this purpose is practically negligible, amounting to only 60 watts for the period that the instrument is in use; moreover, the arrangement avoids the necessity for installing a special motor-generator set which would be required if alternating current were used for the transformers. When the interrupted current, which is of the order of 0·1 ampere, is flowing in the primary windings of the torque transformer, E.M.Fs. will be induced in the two separate secondary windings of this transformer, and, if the air gaps are all equal, the E.M.Fs. will cancel each other, since the two secondary windings are connected in opposition; the voltage measured across the two windings would then be zero. If, however, the H-shaped armature has been displaced by the torque, the gaps on one side will be partially closed, and those on the other side opened, the E.M.F. in one of the secondary windings being increased, while that in the other winding is diminished. The voltage measured across the two windings will, of course, be equal to twice the variation in the E.M.F. induced in either one of them.

By means of the slip rings, brushes and leads, this resultant E.M.F. is applied to the secondary windings of the indicator transformer, the primary windings of which carry the same current as the torque transformer. Details of the indicator transformer are illustrated in Figs. 11 and 12, and it can also be distinguished in Fig. 6. The construction is similar to that of the torque transformer, except that the H-shaped armature is fixed and the cores carrying the primary and secondary windings can be adjusted, to vary the air gaps, by means of a micrometer screw. The latter carries a large drum with a scale on its periphery and is operated by a knurled disc outside the casing, as will be clear from the illustrations just referred to. The scale of the micrometer screw can be seen through a window in the indicator when the cover is in position, as also can be the pointer of the centre-zero instrument, which is located just above the scale and in close proximity to it. It is important to mention that this indicating instrument is of the moving-coil type, such as is used with direct currents, a second contact breaker on the motor shaft being arranged to open and close the secondary circuit so as to produce a unidirectional current. A moving-coil instrument is, of course, more sensitive than one suitable for alternating currents, and the former has the additional advantage that the operation of balancing is facilitated by the fact that the pointer will deflect on either side of the central-zero position.

Having described the arrangement and functions of the various parts of the instrument, we may briefly explain the method of taking a torque reading, which is a particularly simple and expeditious operation. To avoid unnecessary wear, the brushes are lifted off the slip rings on the shaft sleeve when the apparatus is not in use, and, before taking a reading, the brushes must be lowered by means of the rocking lever shown in Figs. 2 and 4. A sheet-steel guard is fitted round the slip rings to protect them, as indicated in Fig. 3, but it should be noted that the design of the complete shaft unit does not involve the use of any parts projecting beyond the flanges. When the brushes have been lowered, the current is switched on by means of a double-pole tumbler switch in the bottom right-hand corner of the indicator casing. The small motor operating the contact-breaker then starts and a pilot lamp in series with the primaries of the transformers lights up, thus indicating that the circuit is complete. This lamp can be seen through the circular window shown in the top left-hand corner of the casing in Fig. 5. The resultant E.M.F. from the torque transformer, produced as described above, is then balanced by adjusting the air gaps of the indicator transformer by means of the micrometer screw, which is turned until the pointer of the indicating instrument comes to its zero position. The scale reading of the micrometer drum, as given by an adjustable index

pointer on the left of the drum, is a measure of the torque, from which the horse-power transmitted through the shaft can be calculated, if the speed of revolution is known, with the aid of a constant depending upon the dimensions of the shaft. This constant can be determined either directly, by calibrating the torsionmeter and shaft by a torsion test, or it may be calculated from the known dimensions of the instrument and shaft and the elastic properties of the shaft material. The procedure is identical whether the engine is running ahead or astern, the only difference being that the scale is read in opposite directions, depending upon the direction of rotation of the engines.

The adjustment of the micrometer screw is very sensitive, an almost imperceptible movement of the scale drum being sufficient to disturb the state of balance, as indicated by the centre-zero instrument. The latter, it should be explained, is highly damped, so that its indications are unaffected by cyclic variations in the torque. For this reason the readings obtained represent the mean value of the torque, although, as already stated, its instantaneous value at any point in a revolution can be measured when required, an additional contact maker being fitted for the purpose. In practice, we understand, mean torque readings can readily be obtained to within 0·5 per cent. of accuracy over the normal working range. Various sizes are made to suit shafts, from 1 in. to 24 in. in diameter, and owing to the sensitiveness of the method of measurement employed the overall length of the shaft unit is usually made rather less than four times the shaft diameter. The length can be still further reduced to a considerable extent if special circumstances render this desirable.

CUTTING TOOLS RESEARCH.

At a meeting of the North Western Branch of the Institution of Mechanical Engineers, held on Thursday, of last week, at the Engineers Club, Albert Square, Manchester, Mr. A. C. Sturney, B.Sc., of the National Laboratory, presented his and Dr. W. Rosenhain's report on the "Flow and Rupture of Metals during Cutting," and Mr. J. H. Hyde presented his and Dr. T. E. Stanton's report on "An Experimental Study of the Forces Exerted on the Surface of a Cutting Tool." We reproduced these two papers in abridged form in our issues of January 30 (pages 148 and 151) and February 6 (page 178).

Dealing first with the paper by Dr. Rosenhain and Mr. Sturney, Mr. E. G. Herbert, in opening the discussion, thought they were entitled to ask the authors of the paper to explain a little more clearly what was their conception of what actually happened with regard to the phenomenon of the built-up cutting edge. They were told by them that the built-up cutting edge was actually continuous with the chip. The chip was continually moving, while the portion which the authors referred to as the built-up cutting edge was a stationary body. It therefore appeared that in this case the phenomenon occurred of a moving body moving continuously over a stationary body to which it was permanently attached. He found it rather difficult to form a conception of what was really happening. They were investigating the phenomenon of the built-up cutting edge on a tool which had continued cutting during something less than one revolution of the lathe. He thought that most engineers would be surprised to find a built-up cutting edge on a tool which had done only that amount of cutting, and, in fact, he was not at all sure that they would find a built-up cutting edge on a tool which had continued cutting for any length of time at the excessively slow speed which must have been used in order that the lathe might be started and the cut put on with accuracy, and the lathe stopped, all within the cycle of one revolution.

Another point was the intended and actual depth of cut. The intended depth of cut and the actual depth of cut were always different. He would like to ask Mr. Sturney to give one piece of information which was not in the paper, and that was, how the zero position of the tool was determined. Had the authors fixed the position of the tool before they had carried it forward to put on the cut? Probably the point of the tool had been put just in contact with the bar, so that when the bar revolved it would just rub lightly without cutting, but it was generally recognised that one could not set a cut from a rubbing position of the tool, and that if this were done, it was bound to lead to a wrong dimension.

Referring to Dr. Stanton's and Mr. Hyde's paper, Mr. Herbert said he wished to draw attention to the important series of results which were contained in Fig. 38, in which it was shown that the resistance of cutting fell to a minimum at a certain speed, which was generally in the neighbourhood of 20 ft. a minute. Mr. Hyde had said that they recognised that that was a temperature effect, so he, the speaker, need not go into that. His work had been referred to in the paper, and it was pointed out that in attempting to explain the changes of durability which took place in a cutting tool on a tool steel testing machine, and in the lathe, he had attributed those changes to the effect of temperature on the tool, excluding any effect of temperature on the cutting material.

That was true, because, although he was fully alive to the possibility that temperature might affect the properties of the cutting material, the effect of temperature on unhardened steels had been fully investigated by competent observers. He had examined the results of such observations, and concluded that within the temperature range at which he had been working, the changes occurring could not possibly give rise to the effects which he had found. Therefore, he had been bound to fall back on the changes taking place in the tool as the result of the temperatures, and those changes he had found in plenty. More recently, he had been led to examine that question of the effect of temperatures on soft metals more closely. He had reviewed the evidence which he had collected 15 years ago, and he had made rather extensive experiments of his own. As a result of the experiments of other workers, it was clear that many steels were short at 300 deg. C. By this, he meant their reduction of area in the tensile test and also their percentage extension, were very much less at 300 deg. C. than at lower or higher temperatures. Most of those experiments had been made at rather wide intervals of temperature, and they could only say that the shortness of the material was much greater at 300 deg. than it was at 200 deg. or 400 deg., and very much greater than at 100 deg. or 500 deg. Shortness was known to have an important effect on the cutting qualities of metals. It helped, he supposed, to assist the chip to break up, and it might conceivably affect the cutting force which Dr. Stanton and Mr. Hyde had measured. That was a possible explanation of the dip in the force curve, but he hardly thought it was the explanation. Although 300 deg. C. was a common cutting temperature, he did not think the temperature would be nearly so high under the conditions which were adopted in those experiments—a very light cut and relatively slow speeds.

In his own experiments he had found that many steels showed a curious decline in their property of work hardening on a restricted range of temperatures lying between 100 and 150 deg. C. In other metals, tin, copper and some alloys, the same change occurred at lower temperatures, always below 100 deg. C. With regard to the work-hardening properties of metals, it was known that they had a very important effect on the resistance to cutting. Metals such as manganese steel were impossible to cut, although soft before deformed. Also, Dr. Stanton mentioned in the paper that the effect he had found was dependent on the heat treatment the material had received. If heat treatment were given, the effect might disappear entirely. Mr. Herbert said he had found temperature work-hardening effects had been also dependent on the previous thermal history of the material. They therefore had the durability of the tool rising to a maximum at low speeds which generated moderate temperatures. They had the cutting force as shown descending to a minimum at low speeds, which also denoted moderate temperature. They had the work-hardening properties of the material also going down to a minimum at moderate temperatures which were known in that case to be between 100 and 150 deg. Those were very significant facts taken in conjunction with each other. Unfortunately, they did not know what the temperatures were in the experiments described in the paper.

Mr. E. W. Colbeck asked whether, in connection with Mr. Sturney's statement that the three types of chip were dependent on the top rake angle and depth of cut, it was possible with materials other than brass or mild steel that the same types of chip came off with using smaller top rake angles and depths of cut. He also enquired whether the authors had considered the effect of the local hardening at the deformed zone as a possible cause of tool wear. Referring to another point he mentioned that in those experiments the cut was stopped, and a section through the disc and a deformed zone was obtained. Was that deformed zone continual or did it build itself up, the chip break off, and then another deformed zone get built up; or could the disc be stopped in different positions and a different amount of deformation found?

Mr. Sutcliffe, in reference to Fig. 36 of Dr. Stanton's and Mr. Hyde's paper, asked whether the authors could suggest why the observed normal and tangential components were of the same value as the calculated components of the indenting forces when the cutting angle (included angle) was 40 deg. If this were so, one would assume that the force due to the internal friction of the metal of the shaving was zero at this angle, although there must be deformation of the shaving. Had more acute cutting angles been used it would appear from the diagram that the force due to the internal friction would become negative and the observed components be less than the calculated indenting components. With respect to the assumptions that the normal and tangential intensities of pressure produced by the indenting force of the tool were independent of the cutting angle, he suggested that the action taking place in Mr. Hankin's experiments, which were referred to, were not similar to those of the tool in the lathe. In these experiments a load was applied to the tool and the work drawn underneath the latter. This produced a scratch in the surface of the work and the tool was set to give no cuttings. The whole of the paper referred to, dealt only with scratch hardness, no mention being made of any indentation tests. He could not see why the authors were justified in making this assumption from Mr. Hankin's paper.

Mr. Dempster Smith said that the flow and rupture experiments made by Dr. Rosenhain and Mr. Sturney would require to be carried further to enable a definite pronouncement to be made as to the character of chip. He held the view that at high speeds and with heavy cuts the groove was worn on the top face of the tool, and a small pile of shavings was frequently deposited on the cutting edge. This small pile was continually being removed and replenished. In some experiments he had made he obtained a primary and a secondary cut; the latter was underneath the former, and left the bar at a speed of about one-tenth that of the primary cut. He was somewhat surprised to hear that when in use the backward thrust hydraulic supports had an initial load of 500 lb. and asked if the dynamometer had been calibrated with an initial load of this dimension.

The cutting angle θ given by the authors was 90 deg. minus the top rake angle and minus the clearance angle. A variation in the clearance angle would not effect the vertical force, and it appeared to him that the cutting angle should be 90 deg. minus the top rake angle or the angle ϕ given in Fig. 35A. That was the angle usually accepted in scientific treatises. With regard to the variation in the vertical force with change in the cutting speed shown on Fig. 38, he was of the opinion that this force not only varied with the speed, but with dimensions of cut, material, and when operating on the periphery of the bar the diameter apparently also effected it. Having regard to this, he would like to know what speeds were used in the experiments to obtain the vertical forces shown by the authors in Fig. 31. He attributed this change in the force to a diameter effect of the metal being cut.

Mr. Evans asked whether the forces which were given in the paper—300 lb. and 500 lb.—represented a true pressure on the surface, because, in calculation of the pressure on bearings, engineers had rather got into the habit of looking upon it as the mean pressure. It was quite conceivable that the value of N was infinitely higher than that shown in the paper. He could hardly imagine that if seizures had occurred, one would get them occurring at pressures which were actually those given by calculation.

Mr. Sturney, in replying to the discussion, referred to Mr. Herbert's inquiry as to how a metal could flow over another without a crack between them. In the authors' opinion, it was a question, of the plasticity of the metals. The action of tools in such a case was very analogous to that of extrusion, where no cracking was apparent at all. Mr. Herbert also asked how they had measured the depth of cut. Mr. Sturney pointed out that that was done by the same workmen each time under exactly similar conditions, and if their theory of the direction in which the crack extended were correct, then it followed that if the jags were formed in the way they suggested the actual depth of the cut must be greater than that intended. It was obvious that the irregularity was very much greater when no top rake angle was used, than when a large top rake angle was used. Mr. Colbeck had asked whether the results they had obtained would be applicable to other metals. He thought he could say almost certainly not, because other metals had different strength factors. They might get shear types of chips. They had found that brass and steel did not behave in exactly the same way. Different cutting angles were needed to give the same type of chip in the two metals.

As to the effect of the deformed zone on the wear of the tool, they had made no measurements whatever. If the deformed zone were to move and if it were very much hardened material, then it might have an abrasive action on the tool. But he thought the evidence was that it did not, as borne out by Dr. Stanton's and Mr. Hyde's experiments. Mr. Colbeck also asked, did the whole deformed zone come away and a new deformed zone form? They had made about 20 chips or more in brass of the flow type,

and in every case except that in which the top rake angle of 30 deg. was used, they had obtained a deformed zone exactly of that shape, but of a different size, the area depending on the top rake angle of the tool. The deformed zone seemed to be in the same state of development in each case, but it was very difficult to say exactly whether that was so or not. The area varied with the top rake angle of the tool. Mr. Dempster Smith had referred to the second shaving which came off, and that was a very interesting point. It would lead one to imagine there was something more about the deformed zone which they had not yet discovered. He thought it was quite possible, by using other conditions, higher speeds, &c., to find out a good deal more about it than had been suggested in their paper.

Mr. Hyde, in replying to the discussion, stated that he did not know whether it would be possible to introduce a thermo-couple on the tool itself. He thought that thermo-couples were the only means of obtaining the information they required. It might be possible to check temperature accurately in that way. He thought Mr. Sutcliffe was rather under a misapprehension as to the experiments of Mr. Hankin which had been referred to. They were not scratch hardness experiments, but experiments on independent tools, which was somewhat different. He did not think they had been published yet. He was very glad to hear from Mr. Dempster Smith that the amount of clearance angle could not influence results in any way. That was a point on which some criticisms had been offered. With regard to Mr. Dempster Smith's remarks on the calibration of the instrument, in making a calibration they put on the deadweights for the horizontal force and took the readings of both gauges and plotted their difference. The force of 500 lb. that they had initially was reproduced in calibration. It did not matter whether that force was 500 lb. or whether it was 100 lb., the calibration was almost exactly the same. The diaphragm was a still diaphragm. The actual movement was only about $\frac{1}{1000}$ in. for 100 lb. per square inch. The total movements for all the forces were not more than $\frac{1}{5000}$ in. on the diaphragm itself. That referred to the horizontal forces. It was considerably greater for the vertical force.

BOILER-SCALING TESTS.—A series of boiler-scaling tests has recently been carried out by Messrs. F. Gilman (B.S.T.), Limited, on a group of Stirling boilers. Comparisons were made between the results obtained with the use of an ordinary turbine tool and those secured with a "Skatoskalo" electrically-driven apparatus. Operating on two tubes in the front drum of a boiler the turbine scaling tool required an average time of 9½ minutes to complete the work on each tube. With the newer system only 1¾ minutes on the average were required. The saving in time was even greater in the case of the back drum tubes of the boiler, the average times taken by the different tools being 21½ and 4½ minutes respectively. Further tests were made when rate of surface scaling by hand was compared with that of the "Skatoskalo" tool. The areas cleaned were 2·39 sq. ft. per hour and 14 sq. ft. per hour respectively.

BRITISH CHEMICAL STANDARDS.—The British Bureau of Chemical Standards, whose headquarters are at 3, Wilson-street, Middlesbrough, and who, as announced in former issues, supply for checking purposes iron, steel, and basic slag standards, several of which were on view at the British Empire Exhibition (see ENGINEERING for September 26, 1924), announce that they are now able to provide the first of a new series of standards, namely, "Iron Ore A," an ore of the hematite class having the following standardised analysis for a sample dried at from 100 deg. C. to 110 deg. C.: iron, 58·19 per cent. (0·12 per cent. insoluble); phosphorus, 0·056; silica, 8·14; sulphur, 0·066 per cent. A more complete analysis of this ore will be given later. As usual in the case of these standards the analysis has been conducted by a number of qualified independent analysts, chemists of works and mines, 14 in all, representative of the different interests involved in the sale and utilisation of iron ores. Quantity of 500, 100, and 50 grammes can be obtained on application to the Bureau.

PICCADILLY CIRCUS TUBE STATION.—It is announced that the Piccadilly Circus tube station is about to be entirely rebuilt. The necessity for this work will be evident when it is realised that since the existing station on the street level was opened in the year 1906 the traffic has increased from 1½ to 18 millions of passengers per annum. It is intended that the new station about to be built should have an annual capacity of 50 millions of passengers. Situated about 15 ft. below the level of the ground this station will be oval in shape, and from it nine escalators will serve the platforms. Five of these stairways will lead from the booking hall to a landing stage from which the other four will diverge, one pair leading to the Piccadilly and the other pair to the Bakerloo lines. By thus speeding-up the flow of traffic it is expected that it will be possible to load 100 trains per hour travelling over these two lines. The booking hall will be equipped with 15 passimeters for the automatic supply of tickets to travellers.

THE LATE DR. FRANÇOIS SCHÜLE.

WE regret to record the death of Dr. F. Schüle, for more than twenty years Director of the Swiss Federal Institution for Testing Materials at Zürich and also Professor of the Technology of Building Materials at the Federal College of that city. Schüle was born in Geneva on November 24, 1860, and was trained at what was then the Zürich Polytechnikum. After leaving college he was for ten years connected with Messrs. Eiffel, whom he represented in the latter part of this appointment in Cochin China and in the Philippine Islands. When the Birs Bridge at Münchenstein collapsed in 1891, he was elected Supervising Engineer of Bridges by the Swiss Railway Department, a newly created office. In the Institution for Testing Materials he was the successor of the founder of this institution, L. von Tetmajer, and he became an authority on the strength of ferro-concrete. Particularly important were his researches on hydraulic limes, mortars and Portland cement, and, further, on the strength of cast-iron and iron generally; his contributions to the investigation of fractures, impact tests, and autogenous welding are equally well known. As regards ferro-concrete, he was largely responsible for the Swiss regulations of 1913, and for the industrial development of ferro-concrete structures in his country and elsewhere. He improved many methods of testing and was a man of broad views. A very active and conscientious worker he was compelled to retire through failing health in 1923.

THE LAUNCH OF THE CUNARD LINER "ALAUNIA."

LAUNCHED on February 7 from the Clydebank yard of Messrs. John Brown and Co., Limited, the twin-screw steamer Alaunia is the twelfth of the 13 vessels comprised in the building programme of the Cunard Steamship Company, Limited, decided on at the time of the Armistice. The extreme length of the Alaunia is 540 ft., the moulded breadth 65 ft., and the moulded depth to the shelter deck 45 ft., while the gross tonnage is 14,000. Designed for the Canadian service, she will carry 520 cabin and 1,040 third-class passengers. A double bottom extends fore and aft for the complete length of the ship providing deep tanks and spaces for the carriage of oil fuel. General cargo accommodation amounting to 400,000 cub. ft. is available, divided into seven compartments. The vessel is intended to have a speed of 15 knots, and the propelling machinery will consist of two sets of steam turbines of the Parsons type driving the screws through double-reduction helical gearing. Each set will comprise a high-pressure turbine driving one pinion of the first reduction gearing and a low-pressure turbine driving the other pinion, the second reduction pinions engaging with the geared wheel on the particular shaft driven. About 8,500 i.h.p. will be developed. The thrust from the four-bladed manganese-bronze propellers will be taken up by adjusting blocks of the Michell type.

Steam will be supplied from two double-ended and two single-ended boilers of the multitubular type, working at a pressure of 220 lb. per square inch and burning oil on the Wallsend-Howden pressure system. Two impulse turbines running at 5,000 r.p.m. and geared to three-wire direct-current generators having an output of 300 kw. will supply power for electrical purposes. Energy at two pressures—namely, 220 volts for power and 110 volts for lighting—will be available. The vessel is classed 100 A.1 at Lloyd's, and will meet the requirements of the British and American authorities in all respects.

AIR MINISTRY SCHOLARSHIPS.—The Air Ministry announces that "Wakefield" Scholarships have been awarded to Flight Cadets John Clarke and R. J. Drummond-Brown, and the "Hyde Thomson" Memorial Prize, has been won by Flight Cadet C. W. Cooper. The "Wakefield" Scholarships were instituted in 1920 by Sir Chas. Wakefield, Bart., C.B.E. The "Hyde-Thomson" Memorial Prize was founded in 1919 by Mr. R. D. Hyde-Thomson for the promotion of proficiency in wireless telegraphy, in memory of his son, the late Lieut.-Colonel Douglas Hyde-Thomson, R.A.F., who was killed on duty whilst flying.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.—Arrangements have now been made for the holding of a show at Chester by the Royal Agricultural Society of England from Tuesday, July 7, to Saturday, July 11, 1925. Prizes to the value of 16,411*l.* are offered in connection with the various events, and a Forestry Exhibition held on similar lines to that at Leicester will take place in the Chester showyard. An interesting feature of the proceedings will be the holding of trials for sugar beet root lifting machinery. Two classes are provided for apparatus made in the United Kingdom. Further information may be had on application to the Secretary, at 16, Bedford-square, London, W.C.1.

BERGINISATION AND CRACKING.

THE paper on "Decomposition of Paraffin Wax at 450 deg. C. in the Presence or Absence of Hydrogen under High Pressure," which Messrs. H. L. Waterman and J. N. J. Perquin, of the Technical University at Delft, Netherlands, read before the Institution of Petroleum Technologists on February 3, seemed hardly likely to attract the engineer. But it was really offered as a "Contribution to the Knowledge of the Bergius Hydrogenation Process." The authors are well-known leaders in this research, and their selection of paraffin wax as their material, was merely due to their wish to have some definite compound to experiment with and not some indefinite mixture of oils or hydrocarbons.

A few years before the war Dr. F. Bergius began to study reactions at pressures of several hundred atmospheres and at temperatures of 400 deg. C. and more, in a steel bomb fitted with a special conical joint.* Charging his bomb entirely with coal and water (not steam) he obtained carbon dioxide and hydrogen; from hydrogen and cellulose or peat he prepared a kind of anthracite in some hours by a conversion for which Nature might have needed millions of years; later on—and this line seems to have been taken up again recently—he prepared oils from coal and hydrogen. In another line of research he treated oils with hydrogen at 100 atmospheres and 400 deg. C. and he thus "cracked" oil under initial addition of hydrogen. This latter process has become known as "Berginisation"; it has been worked by Bergius at Rheinau, near Mannheim, on a fairly large scale and has been submitted to a systematic research by Professor Waterman, who could only charge his autoclave, however, with 200 grammes of paraffin at a time. There are risks in the experiments; but gas analyses of hydrocarbons become very difficult with small quantities. When Dr. Waterman cracked his paraffin in the ordinary way, he observed the formation of coke—the trouble of many cracking processes—only after two hours; the coke seems to be a secondary decomposition product.

In the presence of hydrogen, no coke was deposited, while less gas and smaller amounts of unsaturated compounds were produced; the hydrogen evidently entered into reaction. The formation of gasoline increased continuously as the heating continued for hours, but was smaller than in cracking during the first half-hour. In the scientific interest it is, of course, desirable to follow the reactions up. But cracking processes do not take more than a quarter of an hour or so, and it would be preferable to concentrate research work upon the first half-hour. That point was not raised during the discussion of the paper by Dr. Dunstan, Dr. Ormandy, Professor Brame, and others who work in this line over here. But the general impression seemed to be that Berginisation does not so far offer commercial advantages over ordinary cracking, which now gives satisfactory motor spirit. It is noteworthy that nitrogen under pressure possesses some of the advantages of hydrogen; any gas under high pressure may simply counteract decomposition. The problems are of great importance, technically as well as scientifically. The independent researches of Bergius, Franz Fischer, and others demonstrate the possibility of the conversion of inferior coal into oil, with an improved general utilisation of our fuel.

ROYAL METEOROLOGICAL SOCIETY.

AT the annual general meeting of this society, held on the 21st ult., at 49, Cromwell-road, S.W.7, Mr. C. J. P. Cave, President, in the chair, the report of the council for 1924 was read and adopted, and the council for 1925 duly elected. Mr. Cave retained the office of president for a second year. The first award of the recently instituted "Buchan" Prize was presented to Mr. W. H. Dines, F.R.S. This award is made for the most important original contributions appearing in the *Quarterly Journal* of the society during 1920 to 1923.

Mr. C. J. P. Cave then delivered an address on "*The Present Position of Meteorology and Meteorological Knowledge*," in which he said the Royal Meteorological Society celebrated its 75th anniversary this year. In looking back one was struck by the great progress made in the past 25 years, largely stimulated by upper air research. Meteorology was at a disadvantage compared with other sciences; the number of posts open to meteorologists was very limited; and support for the society had to come largely from amateurs. The society ought to encourage education in meteorological science. That there was a great lack of this was evident; forecasts based on astrology being current, peculiar theories being propounded, while there were even people who claimed the power of influencing the weather. It was not realised how great were the

* ENGINEERING, vol. xcvi, August 22, 1913, page 262.

SCREW-PROPELLER TURBINES AT WYNAU, SWITZERLAND.

CONSTRUCTED BY THE ATELIERS DE CONSTRUCTIONS MÉCANIQUES DE VEVEY, ENGINEERS, SWITZERLAND.

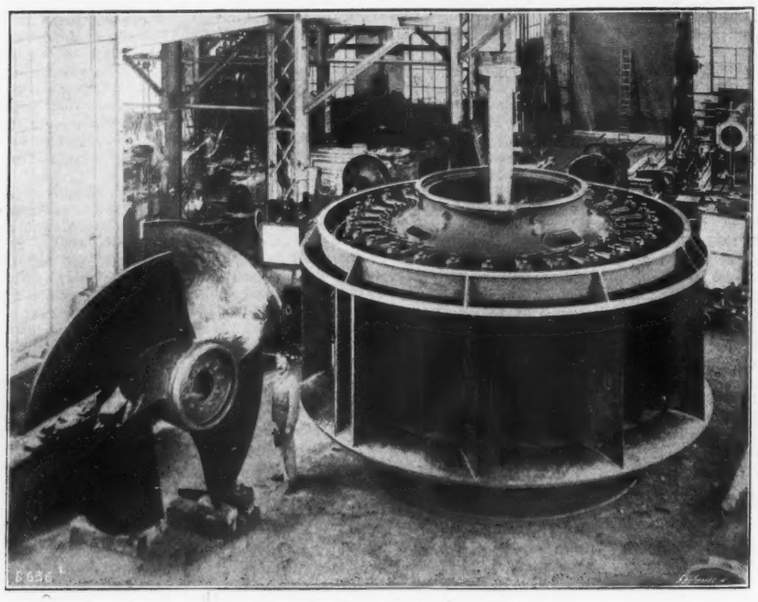
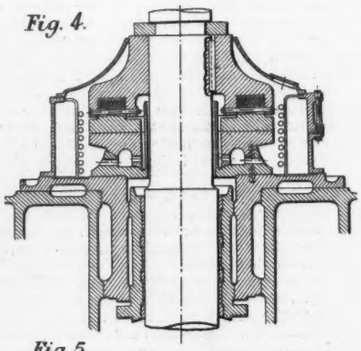
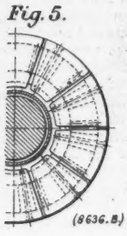
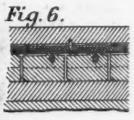


Fig. 3. View of Guide Blades and Runner.







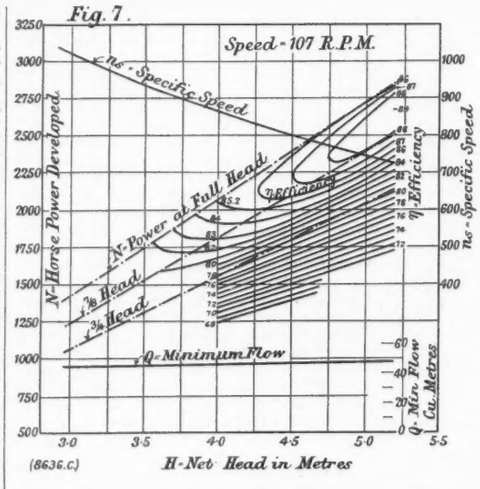
forces in the atmosphere and how little human effort could avail against them.

But it was not only elementary meteorology that should be encouraged; there was a vast scope for research in the science; forecasting was only one of its branches, and except in the matter of forecasting, meteorology in this country was the worst endowed of all the sciences. Was it too much to hope that some great company or some public-spirited individual might come forward to endow a chair of meteorology in one of our universities, and make provision for research. The Royal Meteorological Society was in a position of trust for meteorology, being the only independent body in the country especially devoted to that science. It was true that there was the Meteorological Office, but its position at the present time was an unfortunate one. No sort of criticism was aimed at the present Meteorological Office, but the future outlook was uncertain. In the past the Meteorological Office was directly under the Meteorological Committee, who administered a Government grant. Soon after the war the Office was placed under the Air Ministry; there was no official enquiry before the step was taken. It seems a grave anomaly that the Meteorological Office, which dealt with problems of the greatest importance to many Government departments and to many public bodies, should be solely under the direction of the Air Ministry, more especially when there was in the Department of Scientific and Industrial Research a very suitable body under which it might have been placed.

SCREW-PROPELLER TURBINES AT WYNAU, SWITZERLAND.

Turbines of the screw-propeller type originated many decades ago, one pattern having been patented by Truax in America as far back as 1860; other varieties were proposed by Horton and Williams in 1877 and 1893. Until the advent of hydro-electric stations running on low falls, the type had, however, few advantages, and it failed to make headway against Mr. Francis's modification of the vortex wheel originated by James Thomson. High speeds of rotation are, in fact, generally a disadvantage for anything but electric machinery, for which, on the other hand, they are essential, if capital costs are to be kept down to a reasonable figure.

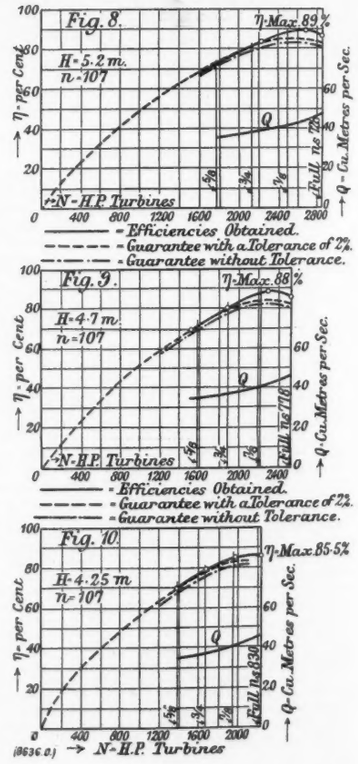
A dozen years ago peripheral speeds scarcely exceeded $\sqrt{2gH}$, where H denotes the effective head and g the acceleration due to gravity. In order to meet the demand for the higher rotational speeds made by generator builders, this figure was progressively raised to double or even treble the foregoing value. With a view to minimising friction losses at these high speeds the number and length of the runner blades were cut down, and these were made with less and less curvature. In this way the runner was ultimately reduced to the screw-propeller type proposed many years ago by Horton and Williams. The lead in this matter has been due principally to Mr. Nagler of Milwaukee and Professor Kaplan of Brunn, and their example was followed by other designers, so that there are now many makers of this type of turbine.



Above and on page 198, we illustrate a pair of these screw-propeller turbines recently erected at Wynau on the Aar River, Switzerland, by the Ateliers de Constructions Mécaniques of Vevey, Switzerland. The available fall here ranges between 2·5 to 5·2 metres, and each turbine was required to develop 2,700 h.p. at 107 r.p.m. The marked progress represented by these new machines is well shown on comparing them with the turbines already installed in the station, which, though of recent date and working with the same head, make only 42 r.p.m. and develop but 800 h.p. each.

A section and plan through the turbines and waterways are reproduced in Figs. 1 and 2, page 198. As will be seen, the alternator is mounted directly over the turbine and driven by a shaft 370 mm. in diameter, which is supported on three bearings. The footstep thrust bearing is a modification of the Michell type, and all bearings have forced lubrication. The water is brought to the turbine through the usual spiral channel, constructed of concrete. The discharge channel is also of concrete and has been proportioned on the results of extensive experiments at the maker's works. The water, in fact, leaves the runner with a speed representing one-fourth to one-third of the total energy due to head, and the conversion of this velocity head into pressure head must be effected with a minimum of loss in order to secure the high overall efficiency demanded.

The draught tube is designed to act as a diffuser. It measures 3,550 mm. in diameter at the runner discharge, and enlarges rapidly towards the mouth. The runner is a steel casting and has four blades, as best seen in Fig. 3, above. These blades are, it will be seen, relatively long, an arrangement adopted to ensure effective guidance of the flow and to



ROTARY CORE-MAKING MACHINE.

CONSTRUCTED BY MESSRS. GEORGE GREEN AND CO., KEIGHLEY.

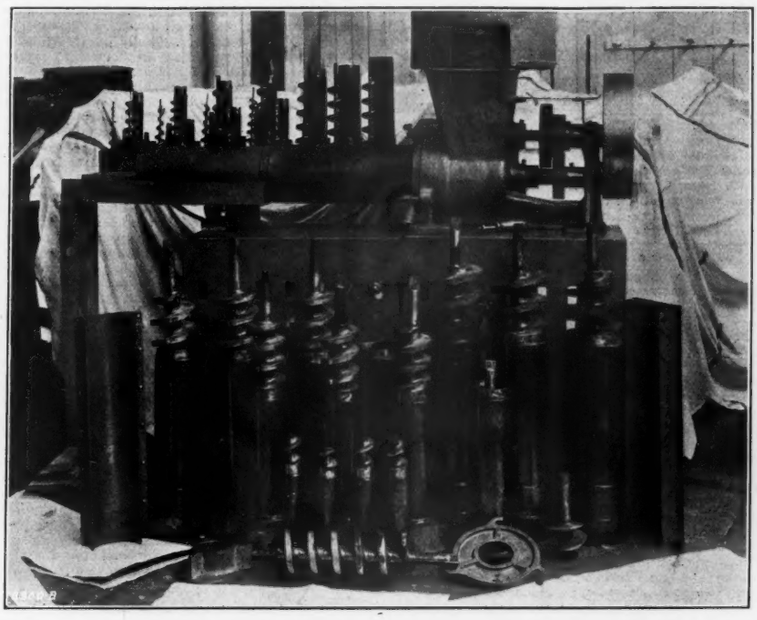
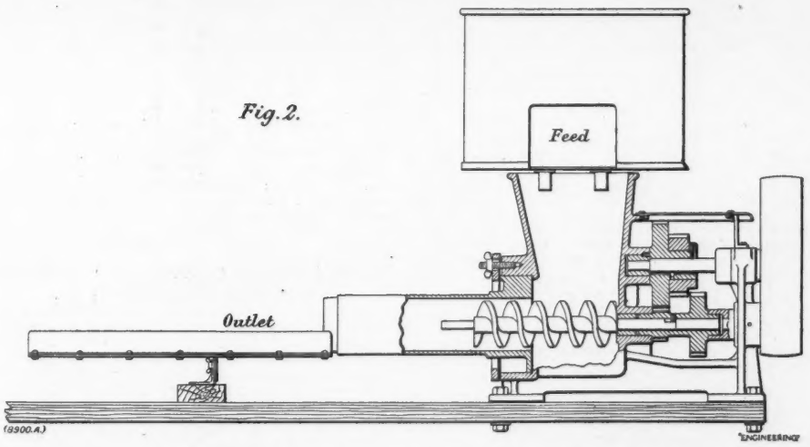


FIG. 1.

Fig. 2.



prevent eddies. It is bolted to a solid flange on the main shaft of the machine and runs within a cast-iron casing, as shown. The dimensions are increased at the discharge end with a view to reducing residual velocities. There are 30 cast-steel guide blades of the ordinary Francis type. The flow is regulated by rotating them about their pivots. The latter run on bronze bushes, and the whole set are coupled together in the usual way. The crank arms are bronze castings, and are designed to have a certain flexibility, so that they may yield locally in case of a hard foreign body getting jammed between a pair of the blades.

Sections through the footstep bearing are reproduced in Figs. 4, 5 and 6, opposite. The total weight supported is 82 tons. As will be seen, the bearings are of the Michell type. The pads are supported on a spherical seating 940 mm. in diameter, and to equalise the load flexible rings of a chrome-nickel steel are interposed between the pads and the spherical seating. The oil supply is provided by a two-stage gear pump, under pressure of 220 lb. per square inch.

In addition to the main governing gear, emergency governors are fitted, one of which closes down the turbine should the governor stop, and the other if the speed exceeds 120 r.p.m.

The turbines have a large starting torque and great stability of running, which the makers attribute to the considerable length of the runner blades. The official tests were made by Bureau Hydrometric du Service Féderal des Eaux. The results are shown graphically in Figs. 7 to 10. The maximum efficiency under an effective head of 5·2 m. was 89 per cent., corresponding to a specific speed of 728. This specific speed is the speed at which turbines would have to run if reduced to such a size that it would develop 1 h.p. under a head of 1 m. With a fall of 4 m. the turbine showed an efficiency of 85 per cent., the corresponding specific speed being 862. The output at high and low heads only differed by about 8 per cent. This characteristic is valuable, since it means that the power falls off but little in the case of floods.

ROTARY CORE-MAKING MACHINE.

IN the processes of moulding, whenever machine operations can be introduced, it is usually the case that this can be done with considerable economy. Not only is this true of the actual moulding, but also in the work preparatory to it, such as pattern-making or the preparation of cores. As an example of a machine suited to the production of cylindrical and other cores, the illustrations above are given. They are of a machine made by Messrs. George Green and Co., of Cooke-street, Keighley, Yorks, which is of a capacity suitable for cores from ¾ in. to 7 in. diameter. The machine with dies and conveyors, as shown in Fig. 1, is a set recently supplied to the Portuguese State Railway Workshops, Lisbon. Since we have stated the diameters of cores for which the machine is suitable, it might be thought that these machines are only capable of dealing with circular sections; it is, therefore, necessary to point out that the appliance can also be used for making special sections, such as squares, hexagons, oblongs, ovals, or flats. As the process of making these cores is a continuous and mechanical one, the product can be obtained expeditiously and at very small cost in labour. Not only are the cores turned out by this machine with rapidity in a single piece without joints, but they can be made perfect to size and shape and vented automatically right throughout the length.

The sand for the purpose of the core-making is introduced into a hopper at the top and is fed down into a coned receiver, from which it falls into the spaces between the threads of a spiral conveyor or propeller, driven through gearing by hand or power. For each size of die there is a suitable spiral, and the combinations of these of various sizes are shown beside the machine in Fig. 1. The simple method of clamp-ring fixing, used for holding the dies in place, may be seen in the section, Fig. 2. For making the smaller sized cores, say from ¾ in. to 3 in. diameter, the driving of the spiral may be done by hand, a suitable handle being provided for the purpose, but for larger work driving by belt is resorted to, and the machine, as shown in the illustrations, is set up with a pulley for this method of working. The sand impelled into the die tube is compressed there, but only to the extent necessary to obtain rigidity. The core remains porous throughout its length, and is such that it will not blow.

As the surface of the core, thus made, is very smooth the quality of the surface in the finished casting is all that can be desired. It should be noted that no wires or rods are necessary for reinforcement, and the core can be easily removed, therefore, from the completed job, since it collapses on disturbance. From the die the core is led on to the tray (see Fig. 2), which is provided with a simple form of adjustable rest. This serves the requirements of every class of work. The trays may be speedily adjusted to the height required, and satisfactory working is obtained without the introduction of the rising and falling trays, such as are supplied with some foreign-made machines. As is seen in Fig. 2, a two-speed gear is fitted to the machine; the top speed given by this is used for making cores of small diameter by hand, and the low one for use with the power drive when the product is of large diameter. It will be observed that the bearings of the gear wheels are protected from the incursion of sand, and a shield is placed over the wheels so that falling material, when the hopper is being charged, is deflected from any possible chance of entry between the teeth.

Though the machine is simple and cheap it may be operated with a high speed of production, and the cheapest form of labour may be used in its operation. When dried, the cores produced are of considerable strength. By hand working, speeds of from 5 seconds to 30 seconds per tray length of 2 ft., may be maintained, according to the size of the cross section of the core. A similar machine for making cores up to 3 in. diameter is also a product of Messrs. George Green and Co., and is very convenient in works where small cores only are wanted.

MARINE AND SMALL CRAFT EXHIBITION.—An opportunity of estimating the progress made within the last few years in the construction of small boats of all kinds will be afforded by the forthcoming Marine and Small Craft Exhibition to be held at the Royal Agricultural Hall from March 18 to April 4, 1925. Full details regarding the arrangements may be obtained from the Exhibition Managers, at 13, Victoria-street, London, S.W. 1.

BUSINESS EFFICIENCY EXHIBITION.—The fourth of the series of Business Efficiency Exhibitions was opened in the Central Hall, Westminster, on Wednesday, February 4, by the Rt. Hon. Viscount Burnham. It will close to-morrow, Saturday. In his speech Lord Burnham said that it was necessary that care should be taken that what was saved in the machine shops and foundries should not be wasted at the office desk or behind the counters. Like everything else, good business methods depend upon the choice and use of suitable appliances. It must be remembered, however, that the introduction of machinery in the office can be overdone and that the best of systems may be a hard and even an unprofitable taskmaster. In the display of exhibits are many calculating devices of reliability and simplicity of operation, in addition to the latest types of type-writers, office printing machines, desks, filing and loose-leaf systems and works and office time recorders. It is very desirable that an exhibition of this type should be held annually, as it enables all who seek for the elimination of unnecessary and wasteful labour in their offices to become acquainted with the methods already made available. Through this concentration of products it is easier to make decisions regarding new methods of working, because comparisons are possible between alternative schemes.

SPANISH MINING AND METALLURGY.

In view of statements to the effect that Germany, notwithstanding her reputed impecuniosity, is acquiring a predominant position in the industry and shipping of Spain, the following figures taken from a recent publication of the Paris Comité des Forges will be found of interest. The figures are in metrical tons; they concern the output of the Spanish mines and steelworks for the year 1923, the corresponding figures for 1913 being quoted in brackets: Coal, 5,672,377 tons (3,783,214 tons); iron ore, 3,456,233 tons (9,861,668 tons); manganese ore, 28,635 tons (21,594 tons); pig-iron, 400,270 tons (424,774 tons); puddled iron and steel, 475,696 tons (241,995 tons). Of the total coal output, by far the greater proportion came from Oviedo, in the north of the country, which produced 3,783,169 tons. The coal-mine operatives numbered 43,613, of whom 13,789 were surfacemen. For the whole of Spain the output per man per annum was 190 tons, reckoning the miners alone, and 130 tons reckoning the total number of colliery operatives. Taking the whole of the collieries the average wage per man was 8·90 pesetas (just over 7*s.* at par) per day. The total value of the coal output in 1923 was estimated at 167,783,399 pesetas at the pit-mouth, equal to 29·58 pesetas (about 23*s.* 6*d.*) per ton as an average for the whole country. In 1923 Spain had an output of 299,069 tons of anthracite and 394,268 tons of lignite. The coke production amounted to 743,590 tons, made in 784 coke ovens, owned by 31 works, the most important metallurgical coke plants being in Oviedo and in Vizcaya. Of the total iron-ore output of 3,456,233 tons, Vizcaya contributed 1,583,784 tons, a comparatively low figure owing to strikes, and far below the output for 1913, which was 3,865,000 tons for that district alone. The operatives engaged in iron-ore mining numbered 12,984 of whom 9,786 were surfacemen. The exports of iron ore in 1923 amounted to 1,602,539 tons, of which 1,460,848 tons were shipped to Great Britain. The total iron-ore exports are about half those of 1913. The Spanish pig-iron production, 400,270 tons, compares very favourably with that of the preceding years, 209,792 tons in 1922 and 247,497 tons in 1921. The same may be said of the iron and steel production—namely, 475,696 tons in 1923, as against 314,315 tons in 1922 and 306,258 tons in 1921. The figure for 1923 includes 13,095 tons of puddled iron, made in 16 puddling furnaces, owned by five works. The coal output in 1924 is anticipated to exceed that of 1923; the iron-ore output will be comparatively low owing to lack of demand from abroad, whilst the Spanish iron and steel works will have produced less owing to slackness in the shipbuilding yards and engineering establishments of the country.

NEW PENINSULAR AND ORIENTAL LINERS.

Important additions are about to be made to the fleet of the Peninsular and Oriental Steam Navigation Company, two passenger and mail steamers having been recently launched, namely, the Ranchi from the Hebburn Shipyard of Messrs. R. and W. Hawthorn, Leslie and Co., Limited, and the Chitral from the yard of Messrs. Alexander Stephen and Sons, Limited, Linthouse, Govan. The first-named vessel, intended for the service between London and Bombay, has an overall length of 570 ft., a breadth of 71 ft. 3 in. and a depth of 47 ft.; while the gross tonnage is 16,000. Seven holds, served by an installation of hydraulic cranes, are divided up into mail and bullion rooms, insulated spaces and cargo accommodation. The propelling machinery consists of two sets of four-cylinder quadruple-expansion engines, developing 15,000 indicated horse-power, and giving the ship a speed of 17 knots. Thrust blocks of the "Michell" type are used on the main shafting and the two screws are fitted with manganese bronze blades. Six double-ended boilers of the multi-tubular type arranged for burning oil fuel in conjunction with Howden's forced draught and working at a pressure of 215 lb. per square inch, are employed. Features of the passenger equipment are two hospitals complete with dispensing rooms and surgery and the provision of a lift which operates between the seven decks of the vessel.

The Chitral is noteworthy on account of having been designed with large refrigerating chambers, together with ordinary holds in addition to extensive accommodation for 200 first and 100 second-class passengers. The vessel, one of a new class being built for the Australian mail service, is a twin-screw steamer of 15,000 tons gross, having a length of 546 ft., a breadth of 70 ft., and a depth of 46 ft. A speed of 16 knots on service is intended, and machinery, consisting of quadruple-expansion balanced engines, developing 13,000 indicated horse-power, has been fitted. Steam is supplied by seven boilers burning oil fuel on the "Clyde" system, as in the Ranchi. The installation of cargo gear is extensive, while the electric winches and derricks at each hatch are arranged to load or to deliver cargo on both sides of the ship simultaneously.

BOOKS RECEIVED.

United States Geological Survey. Water Supply Paper No. 514. *Surface Water Supply of the United States*, 1919–1920. Part XII. *North Pacific Slope Drainage Basins* (c). *Lower Columbia River Basin and Pacific Slope Drainage Basins in Oregon.* [Price 25 cents.] Professional Paper No. 92. *The Middle and Upper Eocene Floras of South-eastern North America.* By E. W. Berry. [Price 1 dol.] Washington: Government Printing Office.

United States Bureau of Labour Statistics. Bulletin No. 363. *Wages and Hours of Labour in Lumber Manufacturing* 1923. [Price 5 cents.] Washington: Government Printing Office.

United States Department of Commerce. Simplified Practice Recommendation No. 16. *Lumber.* [Price 15 cents.] No. 17. *Forged Tools.* [Price 5 cents.] Washington: Government Printing Office.

The Principles of Machine Design. By Robt. F. McKay, M.Sc., M.I.Mech.E. London: Edward Arnold and Co. [Price 18*s.* net.]

The British Corporation for the Survey and Register of Shipping. Register of Vessels, 1890–1924. Glasgow: Offices of the Corporation. [Price 3*l.* 3*s.*]

Choosing Your Life Work. By William Rosengarten. Second edition. London: McGraw-Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

Scientific Management Since Taylor. A Collection of Authoritative Papers. Edited by Edward E. Hunt. London: McGraw-Hill Publishing Company, Limited. [Price 15*s.* net.]

Electric Cables: Their Design, Manufacture, and Use. By William A. Del Mar. London: McGraw-Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

Detailing and Fabricating Structural Steel. By F. W. Dencer, C.E. London: McGraw-Hill Publishing Company, Limited. [Price 25*s.* net.]

Structural Engineering. Fundamental Properties of Materials. By George F. Swain, LL.D. London: McGraw-Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

The Elements of Railway Economics. By Sir William M. Acworth, K.C.S.I., M.A., and W. T. Stephenson, B.A. New edition, revised and enlarged. Oxford: Clarendon Press. [Price 3*s.* 6*d.* net.]

The Jutland Scandal. By Admiral Sir Reginald Bacon, K.C.B. Second edition. London: Hutchinson and Co. [Price 5*s.* net.]

Heat Treating: Its Principles and Applications. By Charles H. Fulton and others. Cleveland, Ohio. and London: Penton Publishing Company, Limited, [Price 14*s.*]

Powells' Electric Supply Share Handbook. Compiled by Hubert H. C. Blake. London: Effingham Wilson. [Price 5*s.* net.]

Bituminous Substances. Scientific Progress of Practical Importance during the last Fifteen Years. By Percy E. Spielmann, Ph.D., B.Sc. London: Ernest Benn, Limited. [Price 15*s.* net.]

United States Geological Survey. Mineral Resources of the United States. I: 8. *Bismuth, Selenium and Tellurium in* 1923. By V. C. Heikes. I: 9. *Chromite in* 1923. By E. Sampson and H. M. Meyer. Washington: Government Printing Office.

Scientific Papers Mainly on Electrodynamics and Natural Radiation. By the late S. B. McLaren, M.A. Cambridge: University Press. [Price 8*s.* 6*d.* net.]

Imperial Institute. Monographs on Mineral Resources with Special Reference to the British Empire. Antimony Ores. By Edward Halse, A.R.S.M. [Price 5*s.* net.] *Bismuth Ores.* By Robert Allen, M.A., B.Sc. [Price 3*s.* 6*d.* net.] London: John Murray.

Meteorological Office—Air Ministry. British Rainfall, 1923. *Report on the Distribution of Rain in Space and Time over the British Isles.* 1923. London: His Majesty's Stationery Office. [Price 15*s.* net.]

Contracts.—We regret that in our issue of January 30 (page 137 *ante*), in recording that Messrs. Frank How and Co., Trogon Wharf, High-street, Stratford, had obtained an important contract for aeroplane engine oil from the Air Ministry, an error was made in the name of the brand, which should have been given as Trogon.

La Voulte, France.—In connection with the account in our issue of last week (page 157 *ante*), of the repair of La Voulte viaduct, as it is possible that some confusion may arise as to the situation of this work, we may state that the town from which it takes its name is on the Rhone, some 124 km. (about 80 miles) south of Lyons, on the P.L.M. Railway. La Voulte was particularly well known at one time, owing to the fact that one of the important works of the Compagnie des Fonderies et Forges de Terre Noire, La Voulte et Bessèges, was situated there. This firm, founded in 1819, played an important part in the early days, in the manufacture on a large scale of ferro-alloys and the development of steel production. It had associated with it such well-known French metallurgists as MM. Jordan, Euverte, Pourcel and Gautier. M. Pourcel, it may be added, is now an Hon. Vice-President of the Iron and Steel Institute, and was, in 1909, awarded the Bessemer Gold Medal.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel Trades.—While the majority of manufacturers are endeavouring to develop confidence by presenting an optimistic front, the position so far as the general steel and engineering trades are concerned shows little actual improvement. Here and there works are to be found that have benefited substantially from recently-placed contracts, mainly on transport account. Such works are operating at something approaching full capacity, and in a few cases could, it is reported, find employment for more highly-skilled operatives if these were available. The general run of manufacturing businesses, however, have made little progress during the past month. In some instances order books are in a more depleted condition than was the case at the close of last year. The revival promised in raw and semi-finished materials has not materialised. The threat of labour troubles on a widespread scale affecting allied industries appears for the time being at any rate to have killed any disposition there may have been on the part of the big consumers to come forward with long-dated contracts. Buying of forge and foundry iron, hematites and all classes of scrap is as much of a hand-to-mouth character as was the case a month ago. Prices are depressed, but with production already restricted there has been no further shading of official quotations. Mild steel continues to feel acutely the pressure of competition from Continental manufacturers who have nothing like an equal burden to bear in the forms of national taxes. Bars and billets of Belgian manufacture are available at pounds per ton below the cost of the local product, though manufacturers with a reputation to maintain, hesitate to use cheap materials of this class because of the mixed results obtained in treatment. Production of high-grade steels is in the ascendant at individual firms, though, in accord with the generally mixed nature of local working conditions, other concerns specialising in similar lines report a diminution in the current demand. The extent of foreign inquiries leaves no doubt as to the high reputation which these steels have won among overseas engineers, but the price difficulty tends to become more pronounced with the rise and spread of hostile tariffs. The tool trades as a whole are making slow progress.

South Yorkshire Coal Trade.—A slight improvement is to be recorded, but on the whole conditions remain unsatisfactory. Best steams continue to occupy a strong position on home account, but tonnages going away for shipment show a further decrease. Cobbles and nuts are finding a better market while slacks maintain their recent improvement. House coal is in better request, but considering the time of year, leaves much to be desired. Foundry and furnace coke are going away in bigger tonnages for home consumption, while exporters show no tendency to increase their requirements. Quotations: Best branch handpicked, 30*s.* to 33*s.*; Barnsley best silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 31*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*d.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 19*s.* 6*d.* to 23*s.*; Derbyshire hards, 19*s.* 6*d.* to 22*s.*; rough slacks, 9*s.* 6*d.* to 12*s.*; nutty slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; smalls, 4*s.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is still quiet, and very largely confined to transactions with home customers. Local needs are rather considerable, and Scotland continues to take fairly good parcels, but overseas sales are still on a very limited scale. Small odd lots have been sold to the Continent, and America has purchased fair parcels of the descriptions of iron usually taken by the United States, whilst some inquiries for foundry iron for transatlantic shipments are circulating. Makers' stocks of ordinary Cleveland pig-iron available for disposal are small, but quotations are weak. No. 1 is offered at 84*s.* and possibly that figure could be shaded; up to 79*s.* is still asked for No. 3 g.m.b., but 78*s.* 6*d.* has been accepted: No. 4 foundry is on sale at 78*s.*; and No. 4 forge is quoted 77*s.*

Hematite.—Demand for East coast hematite is only moderate, and there is keen competition for orders that come on the market. Makers still hope to do rather considerable business with America. Fairly good local sales are reported, and further sales to Sheffield customers are stated to have been made, whilst Continental inquiries, though still on a very small scale, are slightly better. Supply, however, is very ample and values are on the downward curve. Nos. 1, 2 and 3 have been sold at 86*s.*, and that may now be given as the general market quotation. No. 1 is put at sixpence above mixed lots.

Foreign Ore.—There is little or nothing doing in imported ore. Sellers still base market rates on best rubio at 22*s.* c.i.f. Tees, but it is difficult to ascertain on what rates contracts might be made.

Blastfurnace Coke.—Durham blastfurnace coke is selling fairly well for local use. Good medium qualities are quoted 24*s.* to 24*s.* 3*d.*, delivered to consumers here.

Manufactured Iron and Steel.—Manufactured iron is rather slow of sale, but producers are not badly placed. Semi-finished steel is in only very moderate request, and demand for most descriptions of finished steel is quiet. Quotations, however, are maintained. Common iron bars are 12*l.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft),

8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* 5*s.*; steel angles, 9*l.*; steel joists, 9*l.* 5*s.*; heavy sections of steel rails, 9*l.* 10*s.*; black sheets (24 in. gauge), 12*l.*; and galvanised corrugated sheets (24 in. gauge), 17*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—During the past week movement in the Scottish steel trade has been of a very restricted nature. Buyers on the whole are few, and most of the business passing is against contracts placed some time ago. These are being reduced but slowly owing to the general dullness all round, and with the demand on such a small scale plant is only partially employed. The future is not being looked forward to with any degree of assurance, as there are few indications of any marked improvement coming along. From the shipbuilding industry there is a very poor demand, and the boiler-makers also are not sending out many requests at the present time. The black sheet trade continues busy, and a large and increasing demand is reported for the light and galvanised varieties. The heavier gauges are not in such good request. Prices are steady and are quoted as follows:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, $\frac{3}{16}$ to $\frac{1}{8}$ in., 12*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The bar iron makers in the West of Scotland are still badly off for specifications and new business is extremely scarce. The general inquiry does not hold out much hope of things getting any better, in the near future at any rate. In the steel re-rolling branches a certain amount of activity is general, but business is very keenly cut. For "Crown" bars the current price is 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—There would seem to be a decreasing demand for Scottish pig-iron at the present time and it has certainly been small enough of late. The deliveries which have been going through have mostly been from consumers who were making up their stocks and fresh business has been almost nil. Not only has the home trade been quiet, but export lots of any account are a thing of the past a dead letter at the moment. The present output from the furnaces is small, and is largely going into stock with the result that, with the tonnage on hand so large, there is a probability of another six or seven furnaces being blown out almost immediately. The outlook is not by any manner of means encouraging. Prices have eased off and the current rates may be taken as follow:—Hematite, 4*l.* 13*s.* 6*d.* per ton, delivered at the steelworks; foundry iron, No. 1, 4*l.* 11*s.* 6*d.* per ton; and No. 3, 4*l.* 9*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, February 7, amounted to 699 tons. Of that total 496 tons went overseas and 203 tons coastwise. For the corresponding week of last year the figures were 896 tons to foreign ports and 192 tons coastwise, making a total shipment of 1,088 tons.

Decrease in Blast-Furnaces.—Messrs. Wm. Baird and Co., Limited, the well-known ironmasters, have decided to blow out their remaining furnaces until such time as conditions in the trade show an improvement. The furnaces in question number 7, and are 2 on hematite and 2 on ordinary iron, both at Gartsherrie works, Coatbridge, and 3 on ordinary iron at Lugar works in Ayrshire. Of the total number of 102 furnaces in Scotland, Messrs. Baird own 26.

THE INSTITUTION OF GAS ENGINEERS.—It is announced that H.R.H. The Prince of Wales has consented to become an Honorary Life Member of the Institution of Gas Engineers.

THE HANDLING OF STEAM PIPES AND VALVES.—Attention is called by the Board of Trade to the necessity for thoroughly examining periodically fittings subjected to steam pressure and the importance of exercising the greatest care in handling such fittings when under pressure. In notice No. 68, just issued by the Mercantile Marine Department, a case is described in which fatal injuries were incurred by an engineer as a result of failure to blow off steam from a boiler before disconnecting a steam pipe. Such a precaution is strongly advocated in all cases by the Department.

ALMANACS AND CALENDARS.—Monthly tear-off calendars have been received from the International Construction Co., Limited, engineers and contractors, of 56, Kingsway, London, W.C.; Messrs. Marshall, Sons, and Co., Limited, steam engine manufacturers, Gainsborough; Messrs. Ansaldo, Limited, of Genoa, Italy; Messrs. Williams, Lea and Co., Limited, printers, of Clifton House, Worship-street, London, E.C.2.; August's Muffle Furnaces, Limited, of Halifax, and British and Insulated Helsby Cables, Limited. That sent by the last-mentioned firm consists of a calendar in a handsome metal frame, which has tables of use in connection with cable calculations mounted upon it. A weekly tear-off calendar has reached us from Messrs. Urquhart Lindsay and Robertson Orchar, Limited, engineers, of Dundee, while daily tear-off almanacs were sent us by Messrs. Ashwell and Nesbit, Limited, engineers and iron founders, of Barkby-lane, Leicester, and Messrs. Sells, Limited, of 168, Fleet-street, London, E.C.4.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night at 7 p.m., at Storey's-gate, S.W.1. Informal Meeting. Discussion on "Gear Production Machinery." Friday, February 20, at 6 p.m. Annual General Meeting. Adjourned discussion on "Anti-Friction Bearing Applications for Heavy Duty," by Mr. J. B. Dahlerus.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night at 7.30 p.m., at 39, Victoria-street, S.W.1. Hon. Member's Lecture. "Milestones in the Development of the Prime-Mover Locomotive," by Mr. Loughnan Pendred. Friday, February 20, at 7.30 p.m. Lecturette, "Inverted Tooth Chain Drives," by Mr. J. M. Soddon.

THE DIESEL ENGINE USERS ASSOCIATION.—To-night at the Engineers' Club, Coventry-street, W.1. "Submarine Engines and High-Speed Heavy-Oil Engine Electric Generating Sets," by Mr. P. A. Holliday.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, February 14, at 3 p.m., at the Heriot Watt College, Chambers-street, Edinburgh. "Problems in Mechanical Coal Mining," by Mr. Sam Mavor. "Experiments on the Flow of Air in Mines," by Professor David Penman, D.Sc., and Mr. J. S. Penman, B.Sc. "Efficiency of Safety Lamps," by Mr. James Cooper, F.R.S.E. "Seventeenth Century Mining in East Lothian," by Professor Henry Briggs, D.Sc.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH, JUNIOR SECTION.—Saturday, February 14, at 7 p.m., at the College of Technology, Sackville-street, Manchester. Lecture, "Some Foundry Experiences" by Mr. W. H. Meadowcroft.

THE INSTITUTION OF AUTOMOBILE ENGINEERS: BIRMINGHAM CENTRE.—Monday, February 16, at 7 p.m., at the Chamber of Commerce, New-street, Birmingham. "Some Notes on British Methods of Continuous Production," by Mr. F. G. Woollard.

THE BRADFORD ENGINEERING SOCIETY.—Monday, February 16, at 7.30 p.m. at the Technical College, Great Horton-road, Bradford. Lecture. "The Scientific Treatment of Boiler Feed Water, Introducing the Application of Colloid Chemistry," by Mr. W. B. Lewis.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, February 16, at 7.30 p.m., in the Lecture Hall, Mining Institute, Neville Hall, Newcastle-upon-Tyne. "Some Recent Dry Dock Extensions," by Mr. Edward Box, M.Inst.C.E.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH WESTERN BRANCH.—Monday, February 16, at 7.30 p.m., at the Manchester Geographical Society, 16, St. Mary's-parsonage, Manchester. Lecture. "The Design and Construction of the No. 5 Gas-holder for Burnley Corporation," by Mr. A. D. Young.

THE FARADAY SOCIETY.—Monday, February 16, at 8 p.m., at the Chemical Society, Burlington House, Piccadilly, W.1. "The Effect of Superimposed Alternating Current on the Anodic Solution of Gold in Hydrochloric Acid," by Mr. A. J. Allmand and Mr. V. S. Puri. "The Electrolytic Deposition of Cadmium and other Metals on Aluminium," by Dr. C. H. Desch and Miss Eileen Vellan. "The Electrolytic Corrosion of Ferrous Metals," by Dr. W. M. Thornton and Mr. J. H. Harle. "Over-voltage and Surface Forces at the Lead Cathode," by Mr. S. Glasstone. "The Electrolysis of Nitrobenzene with the Mercury-dropping Cathode," by Mr. M. Shikata. "The Law of Distribution of Particles in Colloidal Suspensions: A Note on the Specific Volume of a Gamboge Suspension," by Mr. J. R. Coutts. "On the Distribution of Particles in Colloidal Suspensions," by Mr. W. W. Barkas. Exhibition of Electrochemical Apparatus by Messrs. John J. Griffin and Sons.

THE ROYAL SOCIETY OF ARTS.—Monday, February 16, at 8 p.m., at John-street, Adelphi, W.C.2. Cantor Lectures. "The Inner Structure of Alloys" (Lecture I), by Dr. Walter Rosenhain, F.R.S. Wednesday, February 18, at 8 p.m. Ordinary Meeting. "Modern Atmospheric Conditions," by Mr. J. S. Owens, F.G.S.

THE INSTITUTE OF TRANSPORT.—Tuesday, February 17, at 5.30 p.m. at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Lecture, "The Rights and Duties of Transport Undertakings," by Mr. H. Barrs Davies.

THE INSTITUTION OF CIVIL ENGINEERS.—Wednesday, February 18, at 6 p.m., at Great George-street, S.W.1. Students' Meeting. "Reconstruction of Barrow Haven Bridge, Lincolnshire, L. and N.E. Railway," by Mr. Rustom Hormusji Tangri.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, February 18, at 7.30 p.m., at 49, Cromwell-road, South Kensington, S.W.7. "The Effect of Pressure Distribution upon London's Sunshine in Winter," by Miss L. Doris Sawyer, B.A. "On the Changes of Temperature in the Lower Atmosphere by Eddy Conduction and Otherwise," by Professor Sydney Chapman, F.R.S. "The Measurement of the Lapse Rate by an Optical Method," by Mr. N. K. Johnson, M.Sc., and Mr. O. F. T. Roberts, B.A.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, February 18, at 8 p.m., at the Society's Rooms, The Temple, Dale-street, Liverpool. "Heat Treatment of Tool Steel," by Mr. S. N. Brayshaw, M.I.Mech.E.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Thursday, February 19, at 5.15 p.m. at Albemarle Street, W.1. Afternoon Lecture. Sir William Bragg on "The Properties and Structure of Quartz" (Lecture IV).

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, February 19, at 5.30 p.m., at the Geological Society, Burlington House, Piccadilly, W.1. "Notes on Tin Recovery and Tin Dressing," by Mr. A. L. Simon and Mr. R. O. Simon. "Tin Mining in Malaya," by Mr. L. G. Attenborough. "The Pitting of Alluvials under Arctic Conditions," by Mr. R. Underwood Jarvis.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, February 19, at 6 p.m., at Savoy-place, Victoria Embankment, W.C.2. "Electricity in Mines," by Major E. I. David.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, February 19, at 7 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2. Lecture, "Light Aeroplane Engine Development," by Lieut-Col. L. F. R. Fell.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Thursday, February 19, at 7 p.m., at the Engineers' Club, Coventry-street, W.1. "Vacuum Brake Ejectors," by Mr. J. N. Gresham.

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Thursday, February 19, at 7.30 p.m., at the Griffin Hotel, Boar-lane, Leeds. "The Elimination of Human Waste in Industry," by Mr. R. J. Mackay, B.A.

THE MIDLAND INSTITUTE OF MINING ENGINEERS.—Friday, February 20, at 3.30 p.m., at the Royal Victoria Station Hotel, Sheffield. "Manufacture of Coke Oven Coke," by Dr. E. W. Smith, F.I.C., and Mr. F. S. Townend, B.Sc. "Mines (Working Facilities and Support) Act, Part I, 1923," by Mr. J. H. Cockburn. At 7 p.m., Annual Dinner.

THE INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Friday, February 20, at 7 p.m., in the Council Chamber, Council House, Birmingham. Joint Meeting with the Institution of Mechanical Engineers (Midland Branch) and the Institution of Electrical Engineers (South Midland Centre). "Review of the Work of the First World Power Conference." Speakers: Colonel R. E. Crompton, C.B., M.Inst.C.E., Mr. D. A. Bremner, M.I.Mech.E., and Mr. W. B. Woodhouse, M.I.E.E.

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, February 20, at 7.30 p.m., at the Society of Motor Manufacturers and Traders, 83, Pall Mall, S.W.1. "Grinding Practice," by Mr. H. A. Dean.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: NORTH-EASTERN DISTRICT.—Saturday, February 21, at 5 p.m., at the Municipal Buildings, Blyth. "Five Years' Progress at Blyth, Northumberland," by Mr. L. Leeper. "The Law Relating to the Collection of House Refuse and Trade Refuse," by Mr. J. Leigh Turner.

THE SCIENTIFIC SOCIETY OF THE ROYAL TECHNICAL COLLEGE.—Saturday, February 21, at 7.30 p.m., at the Royal Technical College, George-street, Glasgow. "The Double-acting Two-stroke Diesel," by Mr. J. C. MacLagan.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Despite the fact that the South Wales coal owners have been losing money in every month since the coming into operation of the present national wages agreement, the executive committee of the South Wales Miners' Federation have decided to recommend a conference of the Miners' Federation of Great Britain to ask the owners for a further increase in the minimum wage and in the subsistence rate. They propose that the minimum percentage above the wages paid in 1914 should be increased from 33⅓ per cent. to 43⅓ per cent.; that the present subsistence rate be increased from 8*s.* to 9*s.* per shift; that joint representation by the owners and workmen shall be made to the Government to re-enact Part 2 of the Mining Industry Act, 1920; that the provision in the present agreement for carrying forward deficiencies be deleted; and that membership of the workmen's organisations should be made a condition of employment. In view of the state of the coal industry the miners leaders must be gifted with unbounded optimism to put forward such demands. To increase the minimum wage by the amount asked would mean an advance in South Wales from 42·22 per cent. of the 1915 standard to 59 per cent. above the standard which would add 1*s.* 2*d.* per day to day workers and about 2*s.* per day to piece workers. The suggestion to re-enact Part 2 of the Mining Industry Act of 1920 under which provision was made for the appointment of joint pit committees, &c., is also something in the nature of a surprise when it is borne in mind that the men themselves refused to operate this part of the Act when given the opportunity to do so. The demand that membership of the organisation should be a condition of employment is the hardy annual of the miners leaders to get a 100 per cent. union.

Five and a-half Years in Dock.—The ferro-concrete barge Cretepond sailed from the Cardiff East Docks to-day after lying there for five and a-half years. The barge, which carries 1,300 tons, was built by the British Construction Company, Limited, for the Shipping Controller and came to Cardiff straight from the stocks in Barnstaple in 1919 where she remained until to-day. In reply to a question in the House of Commons in May, 1923, it was stated that 1,615*l.* had been paid in dock dues for the Cretepond and 303*l.* for caretaking, also that she had been abandoned to the underwriters as a constructive total loss, but that liability was disputed and would have to be settled by the courts. The Cretepond has now been sold to Messrs. Bowles and Pollard, Cardiff, for 50*l.*, and is to be used for bunkering and sand ballasting vessels in the Cardiff roads.

SCREW-PROPELLER TURBINES AT WYNAU, SWITZERLAND.

CONSTRUCTED BY THE ATELIERS DE CONSTRUCTIONS MÉCANIQUES DE VEVEY, ENGINEERS, SWITZERLAND.

(*For Description, see Page* 194.)

Fig. 1.

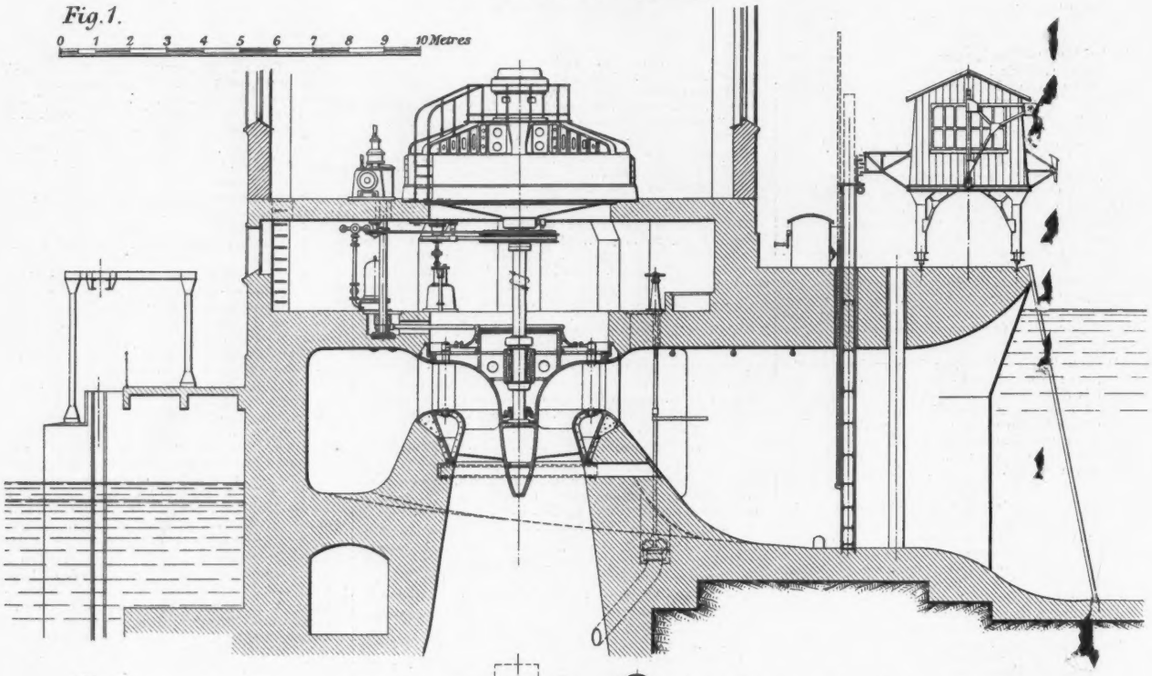
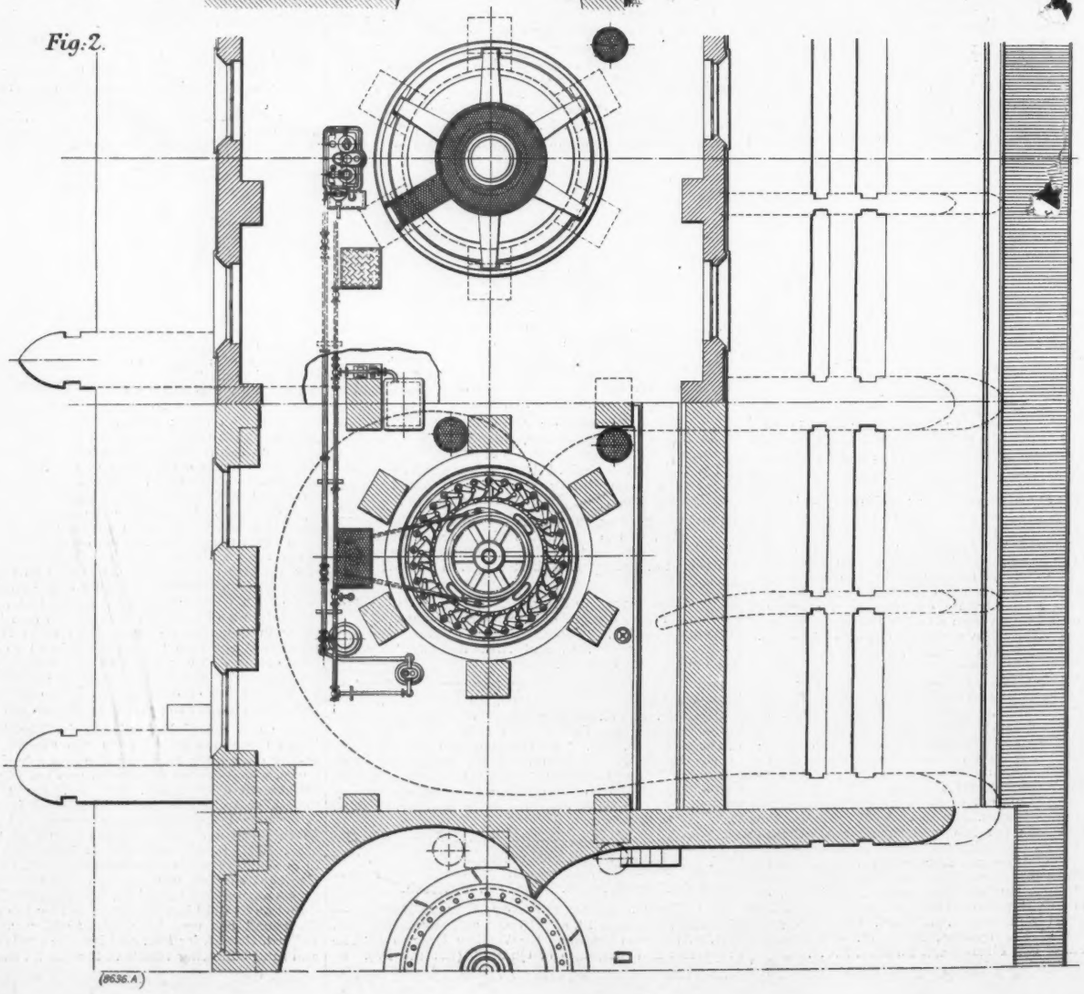


Fig. 2.



JACKSHAFT DRIVE FOR 2-8-2 ELECTRIC LOCOMOTIVE: PENNSYLVANIA RAILROAD.

CONSTRUCTED AT THE COMPANY'S ALTOONA WORKS; MR. J. T. WALLIS, CHIEF OF MOTIVE POWER.

(*For Description, see Page* 186.)

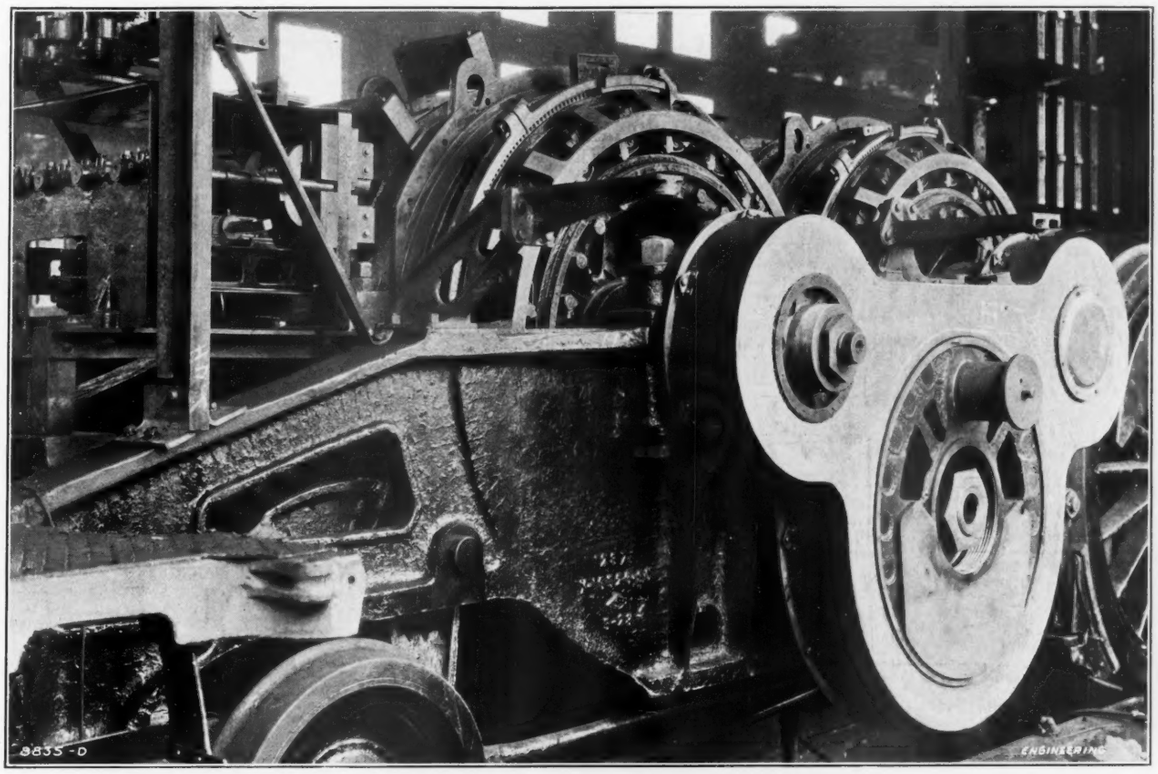


FIG. 55. VIEW SHOWING MOTORS MOUNTED IN POSITION, AND GEAR CASE.

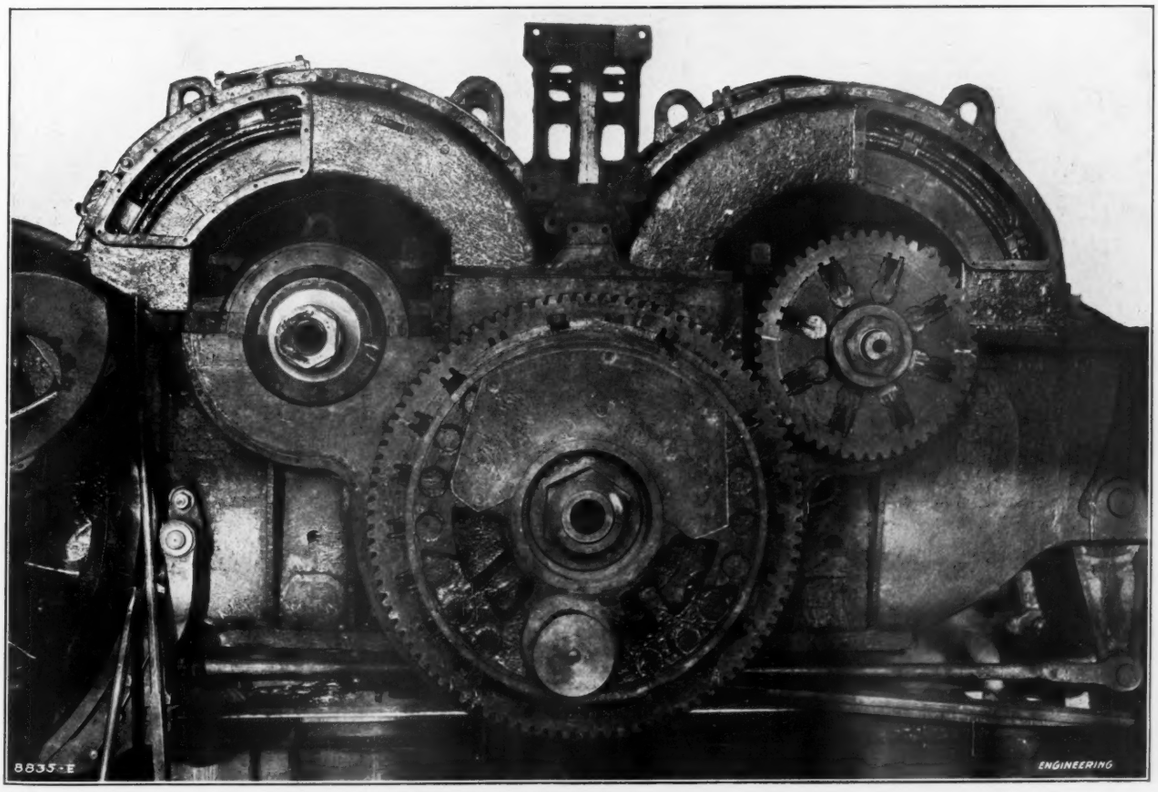


FIG. 56. VIEW SHOWING ARRANGEMENT OF FLEXIBLE GEAR WHEELS.

(*To face page* 186.)

DETAILS OF 2-8-2 ELECTRIC LOCOMOTIVES ON THE PENNSYLVANIA RAILROAD.

CONSTRUCTED AT THE COMPANY'S ALTOONA WORKS; MR. J. T. WALLIS, CHIEF OF MOTIVE POWER.

(For Description, see Page 186.)

Fig. 57.

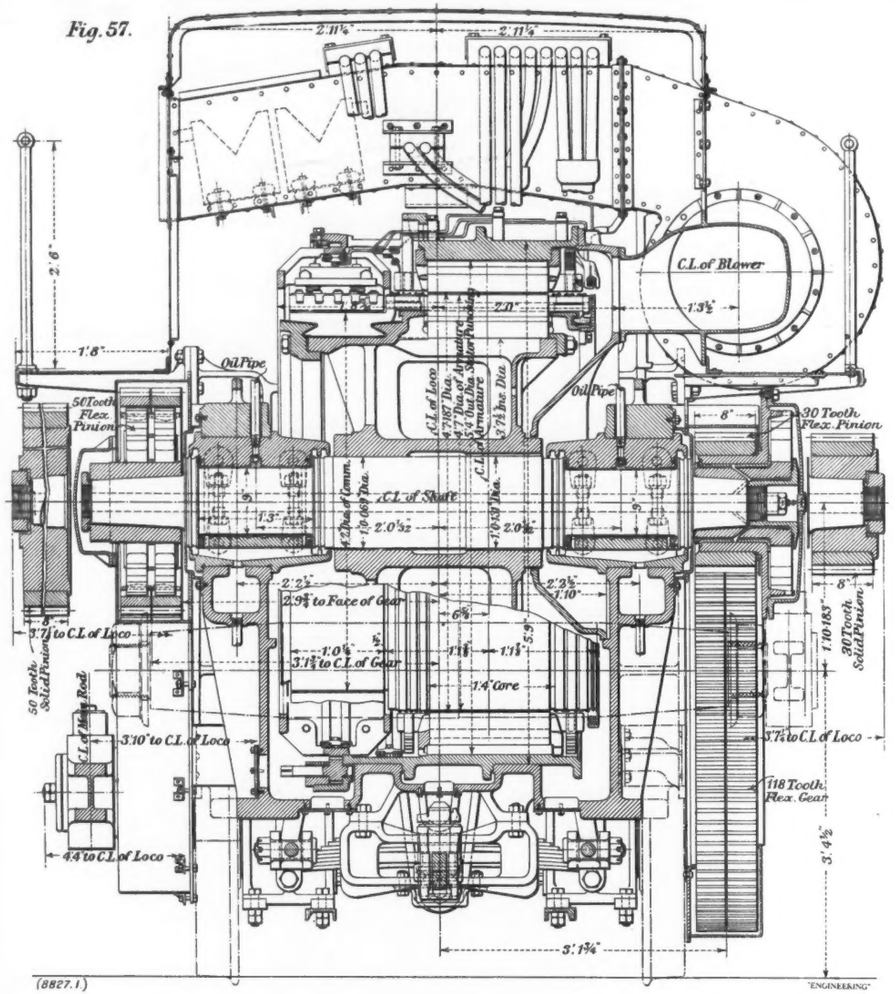
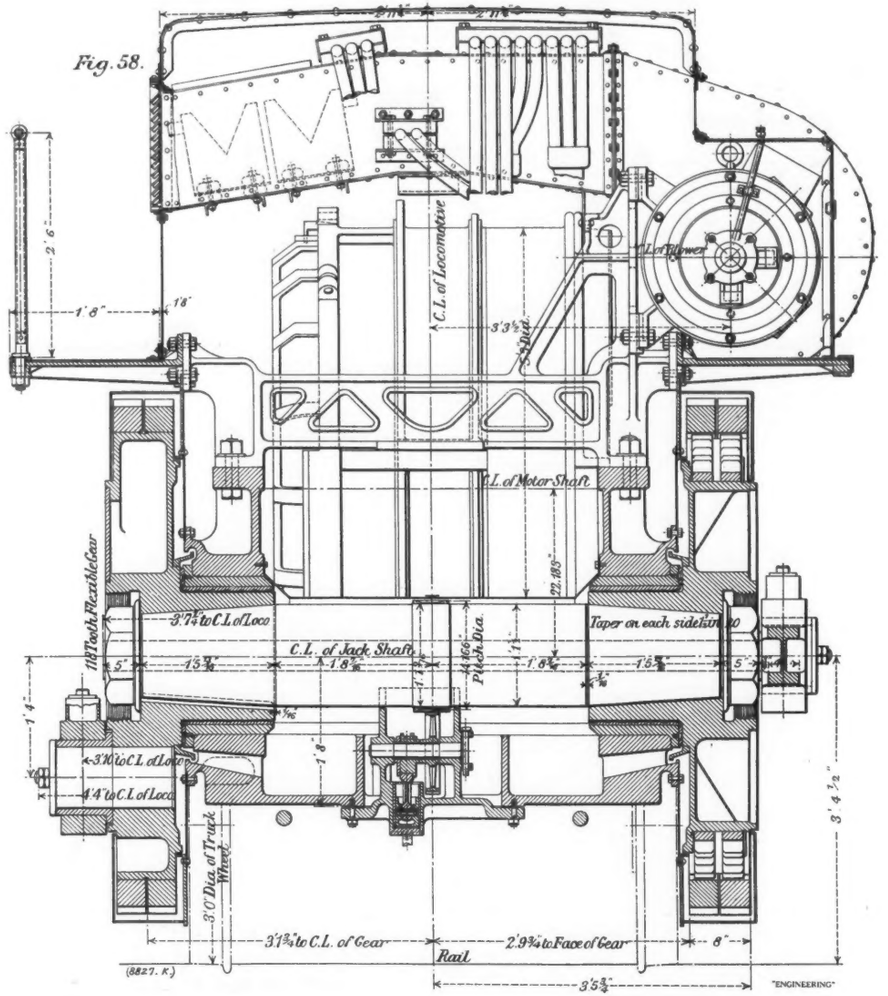


Fig. 58.



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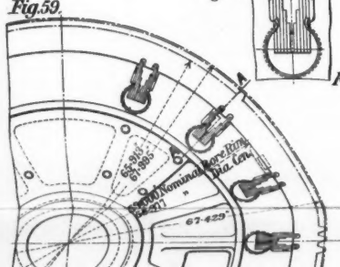

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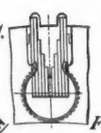


Fig. 62. SEC. A-A.

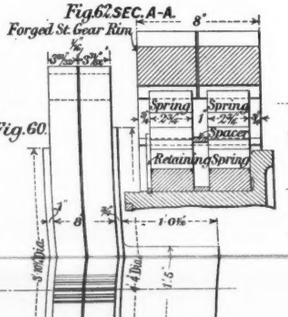


Fig. 60.

Fig. 63.

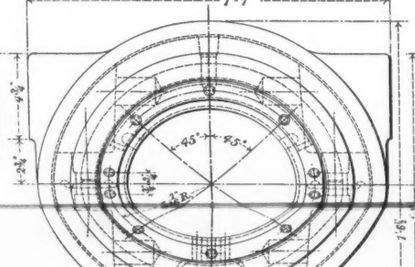


Fig. 64. SECTION C.C.

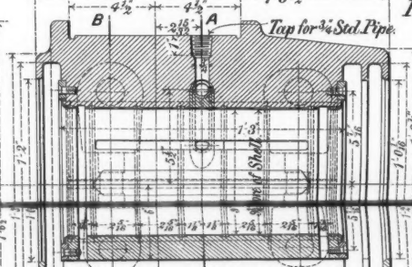
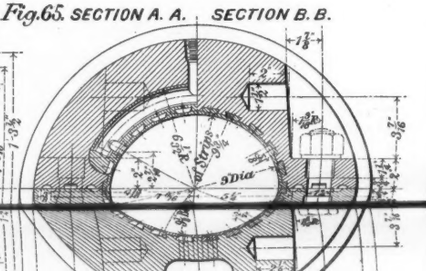
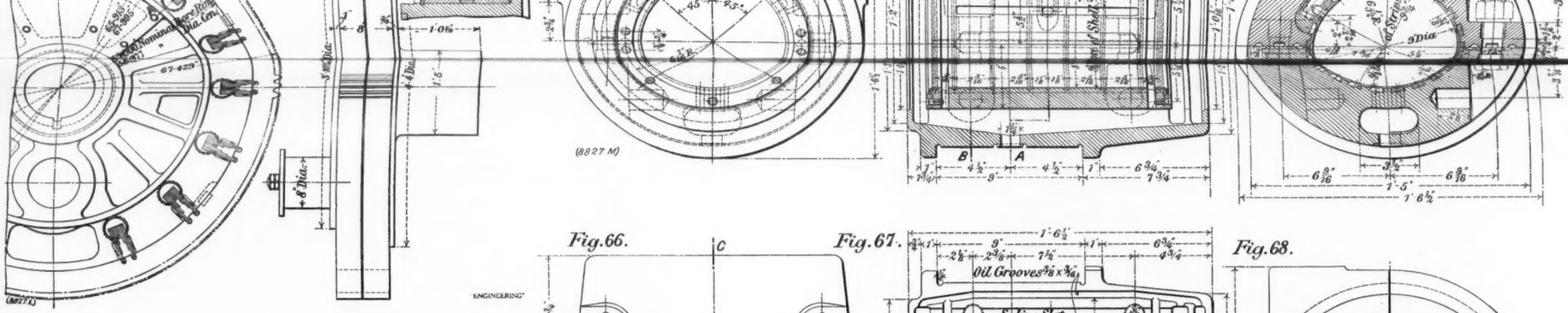


Fig. 65. SECTION A. A. SECTION B. B.





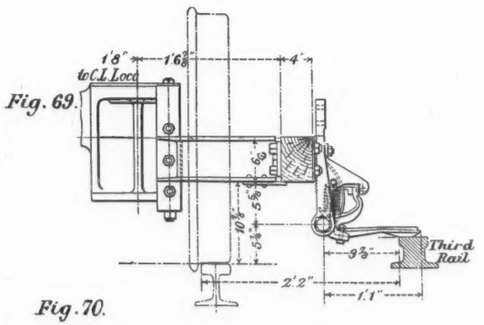


Fig. 66.

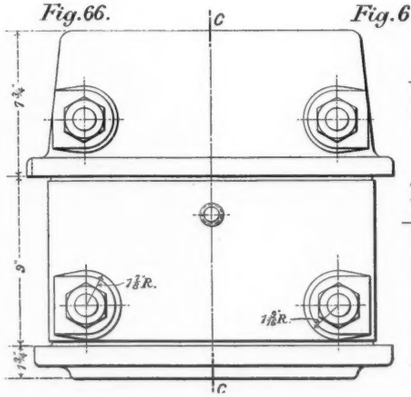


Fig. 67.

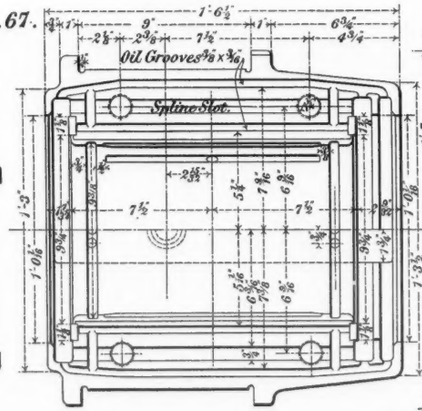


Fig. 68.

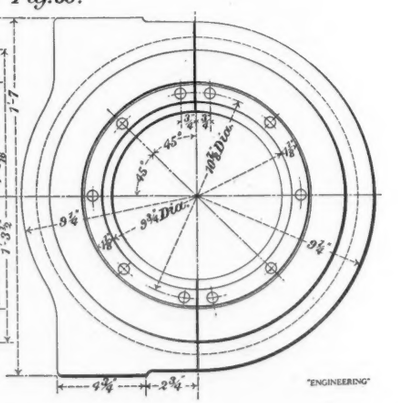


Fig. 70.

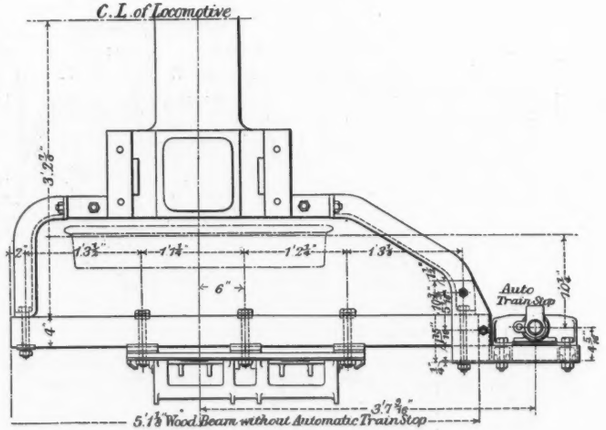


Fig. 71.

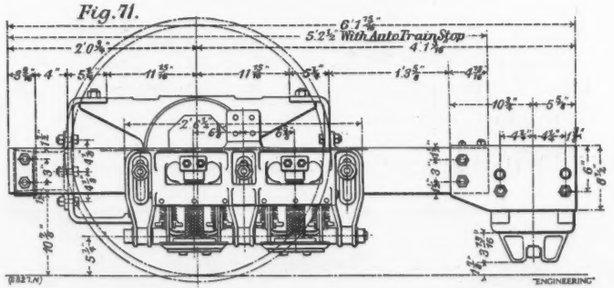


Fig. 72.

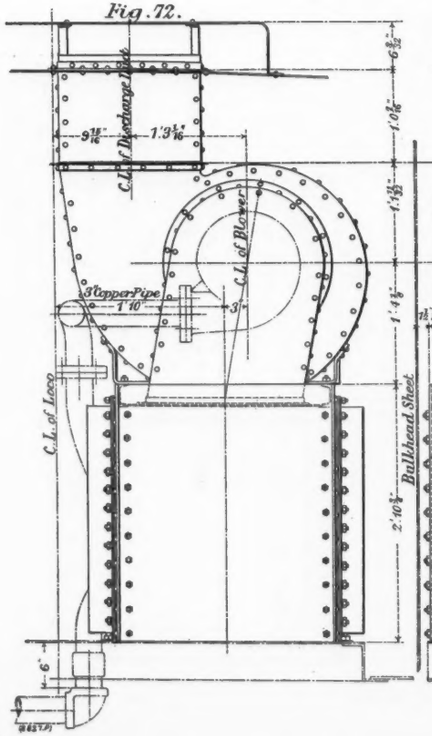
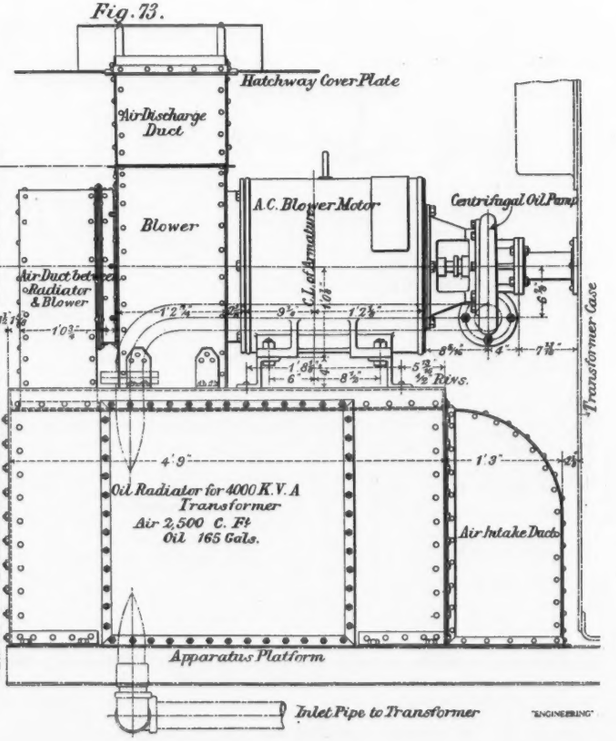


Fig. 73.



AUXILIARY AND CONTROL GEAR FOR 2-8-2 ELECTRIC LOCOMOTIVE ON THE PENNSYLVANIA RAILROAD.

MR. J. T. WALLIS, CHIEF OF MOTIVE POWER.

(*For Description, see Page* 186.)

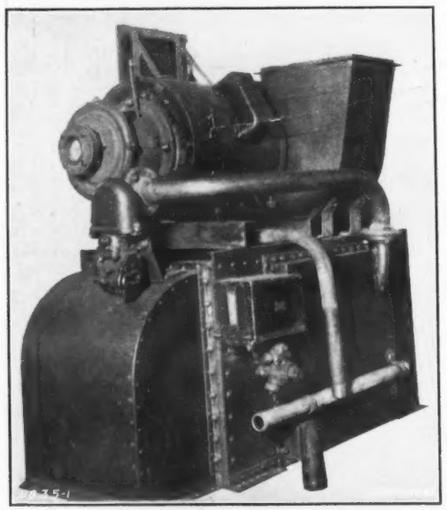


FIG. 74. MOTOR, BLOWER, PUMP AND RADIATOR FOR MAIN TRANSFORMER.

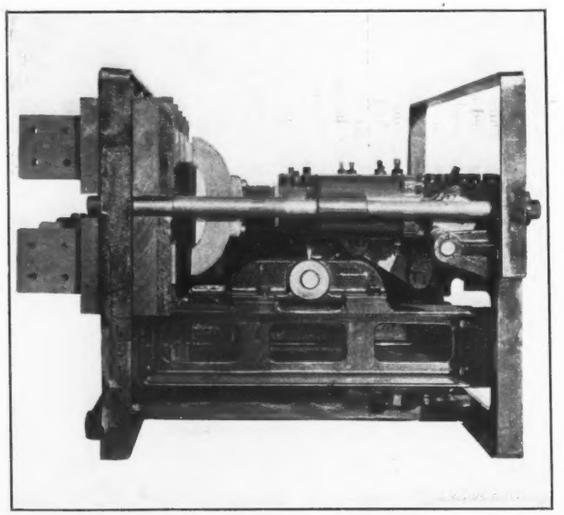


FIG. 75. REVERSER, SIDE VIEW.

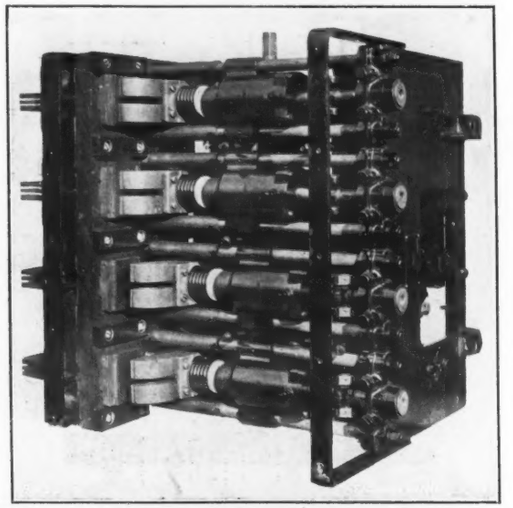


FIG. 76. REVERSER FROM ABOVE SHOWING OPERATING CYLINDERS.

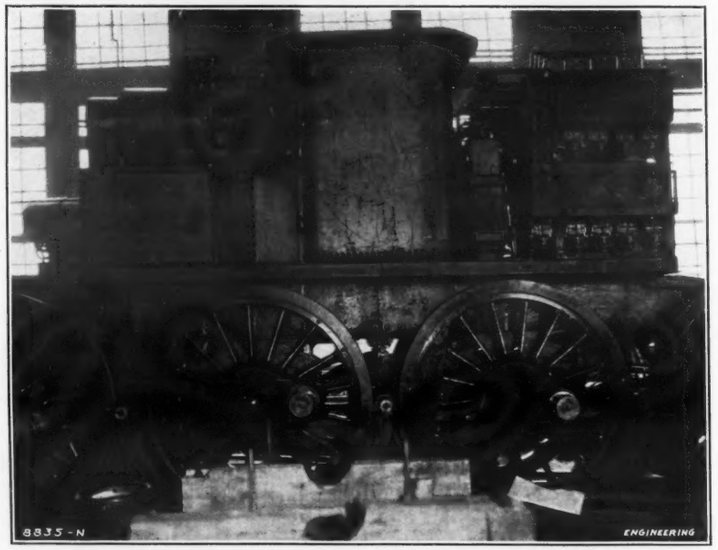


FIG. 77. ASSEMBLY OF MAIN TRANSFORMER AND AUXILIARY APPARATUS IN CENTRE OF LOCOMOTIVE.

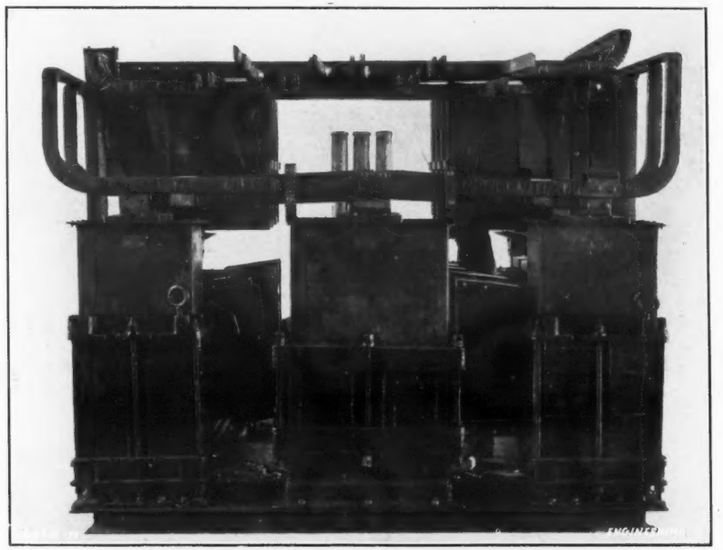


FIG. 78. PREVENTIVE COILS AND UNIT SWITCHES.

(To face page 187.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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One Two-Page Plate and Two One-Page Plates.—2-8-2 *ELECTRIC LOCOMOTIVE ON THE PENNSYLVANIA RAILROAD.*

ENGINEERING.

FRIDAY, FEBRUARY 13, 1925.

CONTINUOUS PRODUCTION IN ENGINEERING FACTORIES.

IN the years immediately preceding the war it was frequently suggested that British engineers were behind those of other nations in organising ability, and the very general absence of works in which mass production methods were employed, was cited as an argument in support of this contention. Many people appeared to believe that it was only necessary to adopt such methods in the automobile trade, for example, in order to rival the output of the great American firms, and in one case at least an attempt was made to put this doctrine into practice. Even at the present time it does not appear to be well enough realised in many quarters that cheap and efficient production is not in itself sufficient to sell an article, but that there are other and more important factors governing the law of supply and demand. In so much as British engineers must in general seek a market beyond our own shores, the problem contains elements which are outside our present sphere, but apart from this it has a number of purely engineering aspects.

As a nation we are decidedly individualistic, and there is no doubt that in the past this characteristic in British engineers has contributed largely to maintain our position in the forefront of engineering achievement. At first sight it would appear that this characteristic renders us as a nation unfitted to profit by mass production systems, as it is generally supposed that the keynote of such methods is the destruction of whatever individuality the workers may happen to possess. Were this the case, we are convinced that any attempt to employ British workmen in production along these lines would inevitably result in failure, as the latter is as fully endowed with his quota of individualism as his employer.

It is by no means certain, however, that mass production methods, when intelligently employed, have the soul-destroying effect with which they are generally credited, nor do we believe that they could have been employed so successfully in the United States if this were the case.

That it is possible for these methods to be successfully utilised in the British Isles was amply demonstrated during the war, as it was only by adopting mass production that we were able to attain an output of munitions far in excess of that of any other nation. It might, however, be said that this was a period during which we were content to sink our individuality, and for this reason especial interest attaches to a paper on "Some Notes on British Methods of Continuous Production" read by Mr. Frank G. Wollard before the Institution of Automobile Engineers on Tuesday last. The paper describes the very successful application of methods of continuous production—or mass production, as it is generally called in America—in the engine works of Messrs. Morris Motors, Limited, and reading between the lines of this paper it is evident that in this case at any rate the individualism of the worker—to whatever extent it may actually exist—has not been found incompatible with the successful working of the system.

The extent to which continuous production methods can be applied successfully in the case of any given firm is dependent entirely on the market of a particular product, and mistakes in the past have generally taken the form of sinking excessive capital in plant without sufficient assurance that the products would find a ready sale. In other words, it is essential that a potential demand should exist before laying down the plant for continuous production, and although it is undoubtedly possible to create a demand in certain classes of goods simply by lowering the price of an article, it must be remembered that the requisite plant is of necessity extremely expensive, and that on this account no lowering of price can result until the sales have reached a high figure. It will generally be found that where continuous production methods are being most successfully applied, as in the case of some of the large automobile firms in the United States, improvements in the productive plant have taken place gradually, and have only been effected when the increasing sales have shown that such improvements were warranted.

It will be evident from what we have said that the first essential of production on such lines is that the article manufactured shall have achieved a firm position in popular favour, and that it shall have been tried out by the actual user to such an extent that no reasonable doubt can exist as to the essential soundness of its design. From this point of view the policy of so many of our automobile firms of introducing entirely new models at frequent intervals is little short of suicidal, as it means in essence that the older models on which the only judgment which counts—that of the purchasing public—has been passed are withdrawn, and that for some time to come sales will be effected on a basis of the reputation of the firm, rather than on the qualities of the article sold. It may appear from this that the adoption of continuous production stultifies improvements in design, but although this danger undoubtedly exists, its importance can easily be over-estimated. That it is quite possible to introduce improvements in design under these conditions of manufacture is amply borne out by an examination of the products in successive years of one or two of the best-known firms manufacturing along these lines, but in making such an examination it is necessary to bear in mind that the original product was essentially sound; and that in consequence any additional improvements have been in the nature of refinements. The limitations to alteration in design imposed by such methods of manufacture may not infrequently operate beneficially, as they tend to rule out doubtful alterations forced upon

the designer by the salesman to meet the whim of the moment. We have frequently had occasion to draw attention to the large number of models manufactured by individual firms in the automobile trade, and although there is a noticeable tendency to cut down in this respect, there are relatively few examples of the policy of a firm concentrating on a single model, which is essential for the most economical production.

We have already called attention to the fact that our industries are handicapped by the restricted size of our home market. In many lines of engineering work this militates against concentration on the manufacture of any particular article, because if a firm is competing in a number of foreign markets it is frequently necessary to turn out a number of different designs to suit the conditions prevailing in different countries. It is usual to apply this argument to the automobile industry amongst others, but in this case the reasoning is largely fallacious. The ratio of cars to inhabitants is so small in the case of the British Isles as compared with certain other countries that it may be said the home market is capable of almost indefinite expansion. The cost of fuel has admittedly a bearing on this ratio, but apart altogether from the possibilities in the direction of cheap home produced fuel, it is certain that a very rich harvest awaits the firm who can put on the English market a car which is as suitable for home conditions as the Ford is in America, and at an equivalent home selling price.

Another field in which we believe that a large potential demand exists for a single model is the Indian market. At present this market is secured almost exclusively by American firms, because the normal American car suits the conditions of the country without alterations. It is, however, reasonable to suppose that if a British firm of good standing concentrated on the manufacture of a single model especially designed for this market, the sales would be found sufficient to justify production on a scale which would make it possible to compete on terms of reasonable equality with American firms.

We have not space at our disposal to deal with Mr. Wollard's paper in any detail, and we must content ourselves with mentioning one or two points which appear to us to be of especial interest. The author states that given the quantities, it is cheaper to make highly accurate work than otherwise. When dealing with small quantities the various machining operations are to a large extent independent of one another, and there is little chance of cumulative errors, but in the case of continuous production on the scale adopted by Mr. Woollard's firm, such errors may assume serious dimensions, though each error in itself may be very trifling. That another policy is possible in the case of small outputs is shown by the ruthless system of scrapping all parts which do not come up to a very high standard, adopted by one of the leading firms.

The probable detrimental effect upon the workman of continuous production methods has been given considerable prominence in the past, and it is pleasing to be able to gather, from Mr. Wollard's remarks on the conditions of employment at the works under discussion, that no such effect actually exists in this case. The author remarks that payment by results and honouring the unwritten laws between employer and employed, together with reasonably comfortable surroundings, would appear to be the solution of the labour difficulty. These suggestions are not new, and attempts to put them into practice have not always met with success in the past. We imagine the key to their successful application lies in the elimination of any suspicion on the part of the employees that they are not being given a square deal, and such a result can only be achieved by the frankest exchange of views on the part of all parties concerned.

It is also interesting to note that Mr. Wollard's firm do not favour overmuch welfare work or paternalism, and there is no doubt that in the case of many firms the attempt to restrict the freedom of the employees in the selection of their own amusements is somewhat overdone. Any line drawn between desirable welfare work and undue interference with the freedom of the worker must of necessity be arbitrary, and will depend on the age of the employee and the conditions of his surroundings outside works hours, but over-enthusiastic welfare workers are apt to underestimate the intelligence of the average adult worker, and to fail to realise that he views any attempt to control his hours of recreation as an unjustifiable interference with his liberty.

ELECTRIC FORCES AND QUANTA.

On Thursday evening, February 5, Dr. J. H. Jeans, Secretary of the Royal Society, delivered the annual Kelvin lecture to the Institution of Electrical Engineers. He took as his subject "Electric Forces and Quanta."

He said that about 25 years ago Kelvin had spoken of two clouds which obscured the theory that light and heat were modes of motion. These clouds, Dr. Jeans proceeded, had grown till they almost filled the firmament, and the old dynamical theory had given way to the new theories of relativity and quanta. Lord Kelvin regarded an electric force as a stress in the ether, which was supposed to possess two kinds of energy, potential and kinetic, the former being identified with electrostatic and the other with electro-magnetic energy. The difficulty that arose was that, whilst this ether could provide for all kinds of electro-magnetic energy, it failed to explain gravitational energy, and, if "action at a distance" had to be called in to account for this, we might just as well adopt the same idea in interpreting electro-magnetic phenomena.

The condition had finally been reached, Dr. Jeans said, that the only satisfactory possibility was no ether at all. The development of the theory of relativity had, in short, given the death blow to the old luminiferous ether of Kelvin, Maxwell and Faraday. The main result of the theory of relativity was that all the phenomena of nature went on as if there were no ether at all. From the point of view of Maxwell and Faraday, an observer moving through a stationary electrostatic field would observe no magnetic effects, since the ether on this hypothesis would have no kinetic energy. Actually the magnetic forces observed were the same, whether the electrostatic field moved past a stationary observer, or whether the observer moved past a stationary field. Hence, if an ether existed it must be something very different from the Maxwell-Faraday ether. The latter had been, in fact, abolished by Einstein's paper, published in 1905, which showed that all electromagnetic phenomena might be thought of as occurring in a four dimensional continuum in which it was impossible to separate space from time in any absolute manner. In a second paper, Einstein had shown that if this four-dimensional space was not of the Euclidean type, the phenomena of gravitation could be explained. Gravitation was on Einstein's theory attributed to kinks and twists in the time-space continuum in the neighbourhood of the gravitating masses, and it was just as inaccurate to say that the sun attracted the earth as to say that a bowl on an uneven bowling green was attracted or repelled by the other bowls.

Einstein's theory had been extended by Weyl who had shown that the geometry of Einstein was not the most general geometry consistent with the doctrine of relativity. On Einstein's theory the length of a 2-foot rule would not be the same if taken from the earth to the stronger gravitational field of the sun. The length would, however, depend solely on the distance from the sun. With Weyl's more generalised geometry, the length of the rule would depend not only on this distance, but on the path by which it arrived there. Weyl showed that there might be distortions, of the time-space continuum, which followed exactly Maxwell's equations.

Einstein's theory, Dr. Jeans continued, could be, and had been, subjected to test, as it led to results differing from the Newtonian theory, but no such test was possible of Weyl's geometry. Gravitation and electro-magnetism, however, fitted in with it, the two systems of forces involved corresponding exactly to the ways in which a four-dimensional geometry could differ from the geometry of Euclid, if these forces were regarded simply as an illusion resulting from the crumpling up of space. He considered this theory as likely to take its place as our final interpretation of the "forces" of nature.

Nevertheless, this generalised geometry had its limitations. It could not explain the difference between positive and negative electricity or the fact that electric charges were atomic, so that the whole of the inner structure of matter, including chemistry, lay outside its scope. There was thus something more in nature than geometry. Something, in fact, limited the distortions which the space could undergo.

Around each electron, there was a limit to the deformation, and there appeared to be a further restriction when two charges were bound together. The restrictions associated with the single electron gave it its charge e and the restriction associated with a pair bound together, gave rise to a second atomic constant. This was generally taken to be Planck's "action quantum" h, but the lecturer suggested that it would be more appropriate to take it as hc where c denoted the velocity of light. This product had the dimension of e^2 and might be regarded as identical with this, save for a numerical constant. On this way of regarding the matter, the two sets of restrictions above referred to would be merely different aspects of the same one, so that the atomicity of the quantum theory was only another aspect of the atomicity of electric charges.

A normal hydrogen atom, he continued, consisted of a negative electron describing a circular orbit about a positively charged nucleus. The quantum restriction compelled this orbit to maintain an unvarying radius of $0{\cdot}53 \times 10^{-8}$ cm. In abnormal states, however, as when the atom was excited in a vacuum tube, the orbit of the electron might have a radius found by multiplying the above value by the square of an integer. According to Maxwell's electrodynamics, an electron describing orbits, as aforesaid, must necessarily radiate energy.

This was found not to be the case. Somewhere before we reached the most minute of all structures Maxwell's theory failed and the quantum theory took its place, but for large-scale phenomena the two coincided. In terms of space-curvature, Maxwell's theory might be represented as a continuous curvature or crumpling of space such as might be applied to a rubber membrane, whilst the quantum theory might be regarded as a "jerky" deformation such as might be given by the curving of a crocodile skin.

In its normal state the hydrogen atom emitted no radiation, but under electric bombardment the electron might, as stated, be raised to other orbits of energy higher than the minimum. There was, however, no gradual change of energy, but only spasmodic jumps from one orbit to another. A jump from an orbit of energy W_2 to one of energy W_1 resulted in the emission of radiation of a frequency fixed by the condition

$$W_2 - W_1 = h\nu$$

where ν was the frequency. This might be written in the form

$$W_2 - W_1 = \frac{hc}{\lambda}$$

where c denoted the velocity of light and λ the wave-length of the radiation. But, as he had pointed out, hc was equal to ke^2, where k was a numerical constant and e the electronic charge.

Now the energy in an orbit of radius r was $\frac{e^2}{2r}$ so that if the jump took place from an orbit of radius r_2 to one of radius r_1, we got

$$\frac{e^2}{2}\left(\frac{1}{r_2} - \frac{1}{r_1}\right) = \frac{ke^2}{\lambda}$$

Hence the wave-length was given by the relation

$$\frac{2k}{\lambda} = \frac{1}{r_2} - \frac{1}{r_1}$$

As already mentioned, by the quantum theory all possible radii were found by multiplying the normal radius a by the squares of the natural numbers. Thus if a denoted the innermost orbit of the hydrogen electron, we got the relation

$$\frac{2ka}{\lambda} = \frac{1}{n_2^2} - \frac{1}{n_1^2}$$

In actual fact it was found that a formula of

this type gave the wave-length of all the lines found in the complicated spectrum of the hydrogen atom.

Whilst the quantum theory accounted for the spectral lines, it was less successful elsewhere, though as regards photo-electric effects it was incomparably more successful than any previous theory. The main fact to be accounted for here, was that the ejection of an electron by radiation depended solely on the wave-length of the latter and not on its intensity. Einstein had suggested accordingly that radiant energy was hurled through space tied up in little indivisible bundles like bullets from a rifle, but it had proved impossible to reconcile this view with interference phenomena.

In a more recent hypothesis Einstein had accordingly suggested that the displacement of an electron from one orbit to another was governed by the laws of chance, and that the difference between a strong and a weak electric field was not that the strong field produced a big change in the velocity of an electron and a weak field a small one, but that the strong field had a big chance of producing the change, whilst the weak field had but a small one.

THE GENERATION OF STEAM.

AT a joint meeting of the Institution of Chemical Engineers and of the Chemical Engineering Group of the Society of Chemical Industry held on Wednesday, two papers were read dealing with novel methods of generating steam. Of these one was contributed by Mr. David Brownlie, under the title of "Steam Generation under Critical Conditions." It dealt with the ingenious proposals of Mr. Mark Benson, which were discussed at some length in our issue of June 22, 1923, page 777, whilst in February 22, 1924, we gave on page 238 particulars of some of the preliminary tests of the boiler erected at the Willan's Works, Rugby, to Mr. Benson's designs. Mr. Brownlie states that this boiler consists essentially of a very long coil of steel tubing, of $\frac{3}{4}$ in. bore and $\frac{1}{4}$ in. thick. This is wound round a vertical cylinder of refractory material about 8 ft. in height, and is covered by a second cylinder. The coils occupy the annulus between the two, which also forms the combustion chamber. In the coil, steam is generated at 3,200 lb. per square inch, and at a temperature of about 706 deg. C., these being the critical temperature and pressure of water. In the upper portion of the coil, the steam is slightly superheated its temperature being raised to 720 deg. F. It is then passed through a reducing valve, by which its pressure is lowered to 1,500 lb. per square inch, and its temperature to about 620 deg. F. This done, the steam enters a superheater 17 ft. high by 7 ft. in diameter provided above the boiler. In this superheater the water condensed by the expansion through the reducing valve is re-evaporated and the steam temperature raised to about 790 deg. F. Still higher temperatures were, Mr. Brownlie states, reached in the preliminary tests, in which the boiler was operated for 6 hours continuously, evaporating 8,000 lb. per hour, this limit being fixed by the capacity of the condensing plant available. The fuel used was oil, and Mr. Brownlie states that the temperature of the waste gases as discharged to the chimney was extraordinarily low.

The object of this method of working was, he explained, to obviate some of the difficulties which have been encountered in earlier attempts to generate steam at extremely high pressures. It has been found that there was liability of the tubes getting burned due to the formation of bubbles, leaving the surfaces dry.

In Sweden an attempt has been made in the "Atmos" boiler to overcome this trouble by keeping the tubes in rotation. The particular feature lies in the long horizontal steel tubes, 12 in. in diameter, which are rotated at 300 r.p.m., with the object of keeping the surface completely wetted by the centrifugal forces developed. In the Benson boiler there is no separation of the water into two phases, and hence no formation of bubbles of steam. The surfaces, therefore, will remain wetted, and the risk of burnt tubes is completely obviated. Mr. Brownlie states that the Rugby tests have shown that there is no difficulty in the continuous generation of large quantities of steam at the critical point.

The second paper to which reference has been made was contributed by Mr. Oscar Brunler and described a boiler in which steam is generated by burning oil below the water surface. That flames could be maintained in such conditions has, of course, long been known, but Mr. Brunler stated that very much experiment was required before continuous working could be ensured. The difficulties were overcome shortly before the war, and when that broke out, 20 of these boilers were on order for various purposes. Mr. Brunler stated that the system had advantages for the evaporation of many liquors in the chemical industries, but he claimed that the system would also provide power very economically, although it would be impossible to adopt the system with condensing engines.

The fuel he uses is crude oil and the air necessary for combustion is supplied to the boiler under a pressure just above the boiler pressure. To start up, the water level must be below the mouth of the burner. The latter is lined with fire-clay and raised to the ignition temperature by a special lamp. When this is done the oil and compressed air are turned on and ignited. The water level is then raised till the flame is drowned, but it continues to burn generating steam. The regulating valves for the air and oil are so arranged that the size of the flame can be reduced or enlarged without altering the ratio between fuel and air. The space above the water level fills with a mixture of steam and of the products of combustion under pressure, and this mixture is employed for driving an engine. It consists of about 60 per cent. of steam and 40 per cent. of the gases, and could not therefore be employed in a condensing engine. Assuming that the boiler pressure is 9·8 atmospheres, and the temperature of the mixture 350 deg. C., Mr. Brunler gives a rough calculation to indicate the possible thermal efficiency. Taking 80 deg. C. as the exhaust temperature and assuming the Carnot cycle with an upper temperature limit of 350 deg. C., he calculates that the 11,500 calories in 1 kg. of oil should yield theoretically 7·82 h.p.-hours. He says that 17 kg. of air are needed for the combustion of 1 kg. of oil, and the compression of this air would theoretically absorb 1·36 h.p.-hours, leaving a theoretical output of 5·46 h.p.-hours from 1 kg. of oil.

In the concluding sections of his paper Mr. Brunler claims that there are certain factors as yet unknown, which lead to combustion efficiencies of over 100 per cent. being recorded. It may perhaps be observed that in his own rough calculation he takes no account of the energy supplied to the flame in the form of the mechanical work done in compressing the air, which amounts to an appreciable percentage of the calorific value of the fuel.

THE PROBLEMS OF HEATING AND VENTILATION.

WHEN men migrated from the country to the cities and the large centres of industrial activity, many problems confronted those who concerned themselves with the continued well-being of the race. The altered conditions under which the people had to live made it necessary that the dwellings and works should be so constructed as to reduce to a minimum the change from the circumstances of their earlier life. Drainage, water supply, the provision of adequate fresh air and the creation of comfortable conditions were the special subjects of interest of those who had to deal with building, but there were, of course, many problems for others in the provision of roads, lighting and the many other conveniences which have become essential to modern industrial life. In every one of these spheres progress, though slow, was continuous and ultimately it became possible to ensure that city and town life should be comparatively healthy. In some cases the problems were of such a nature as to admit of no easy solution, and in these the attainment of satisfactory conditions was only obtained after very lengthy periods. For instance, although it may be contended that the developments in lighting have reached a stage when satisfaction may be expressed, the same cannot yet be said of the subjects of heating and ventilation. The reason for this, no doubt, is that experimental work on these subjects was rarely undertaken, and development was conducted largely on a system of trial and error.

While in certain cases conditions were attained under which comfort was secured it was by no means possible in any given scheme to predetermine that such would be the case. As the size of buildings increased and more and more people were concentrated within them during hours of work, the problems of heating and ventilation became more and more acute, but the subject has been given a great deal of attention by resourceful men, with the result that much has been done to make life, not merely possible, but comfortable, for those who have to spend long hours at their tasks in works, factories and offices.

Much, as has been said, has been done, but there is still much to do. What this amounts to may be judged from a paper presented by Mr. A. H. Barker, on Wednesday, February 11, to The Institution of Heating and Ventilating Engineers at their Annual General Meeting in London. Taking as his theme "Unknown Factors in Heating and Ventilation," Mr. Barker surveyed the whole field and advised continued effort in the direction of experimental work in order to increase the knowledge available to all, so that the effects of the many conditions which cause deviations from an imaginary ideal case may be either correctly counteracted or allowed for. The problems that heating and ventilating engineers have at present to deal with are of two types: those of the working properties of the materials and plant employed, and those of the results which will be attained with the use of these substances and this equipment. During the past ten years much has been done to remove the uncertainty which formerly existed in regard to matters coming within the first category. In this period the heat losses through the best-known heavy building materials have been investigated, as well as some of the lighter structural classes. A fairly complete survey of the gross emission of heat from radiators under standard conditions has also been made. Extension of this work has been undertaken to discover the effects of variation in the placing of radiators and also upon the effects of different types of paint and coverings. A further addition has been made to our knowledge by the analysis of the amount of radiation and of convection. This work is by no means complete as yet, and it is hoped that the earlier investigation on electric radiators may be extended to cover all other types of equipment.

An important piece of work which must be undertaken, sooner or later, is the determination of the resistance to flow of water in the pipes which are actually utilised in heating work. Results obtained with smooth pipes are of little practical use owing to the very different character of the inner surfaces. Fittings and valves must also be experimented with before standards can be established and guarantees of condition obtained from the makers. This matter of pipe resistance is of vital importance to the heating and ventilating engineer. Until it has been properly investigated it is quite hopeless to expect the engineer to be able to predetermine conditions correctly. Indeed, until all the knowledge that is essential to the calculation of the exact temperature which will be attained by a radiator under any conditions, is known, the state of development of the subject of heating must be regarded as far from satisfactory.

Similar basic problems still await solution in regard to ventilation. To-day it is impossible to determine with accuracy what will be the effect of maintaining any specified pressure in the air ducts of a ventilation system. No matter what types of calculations have been and are used, it is not unfair to state that the actual air deliveries are rarely in agreement with them. The determination of the friction in air ducts and fittings is therefore an essential to success. Little experience of ventilation is needed to show that work is frequently entrusted to people who are handicapped by a complete lack of knowledge of the forces operative in causing air flow. Examples can be recalled of exhaust ventilation systems with trunking which increases in cross section as approach is made to the

fan, most of the air, in consequence, being removed from the nearer orifices. It is indeed rather serious that ventilation may still be undertaken by unthinking people, and it is, therefore necessary that the public should be educated to an appreciation that the work is such as should only be given to a recognised expert associated with an authoritative organisation. Mr. Barker stated that the predetermination of the characteristics of fans was still in an unsatisfactory state, and until the losses in the details of fans have been investigated, it must remain impossible for an engineer to decide that any proposed construction will give the greatest efficiency. We are not sure that this is an exact statement of the conditions, for we are certain that there are many fan designers and makers who can and do estimate with a very fair approach to accuracy what their fans are capable of. Those outside the ranks of the actual fan-making industry have not available the resources possessed by the manufacturers, through their own experimental work. Consequently they have to accept the makers' statements without having the means of checking them.

The solution of these and many other problems is clearly desirable, and any effort towards this end is worthy of support. For this reason the establishment of a research fund by the Institution of Heating and Ventilating Engineers must be warmly commended. Through this Institution, as the recognised authority dealing with these subjects, the best experimental skill may be secured for the work, while associated with the Institution there are many authorities capable and willing to interpret the results and put them into a simple and usable form. Once the work already referred to has been done, the field for research will still be a wide one, as it is necessary not only that an engineer should be able to calculate accurately what the temperature and the air movements would be in any part of a building, but that he should also be able to find out what effects are actually experienced, in changes of sensations of warmth and freshness by persons utilising the building.

ALTERNATIVE BUILDING METHODS.

As a consequence partly of the war and partly of well-intentioned legislation which has not merely discouraged but has made practically impossible the building of houses for letting, we have reached such a state of house shortage—particularly in the case of working-class houses—that all sorts of likely and unlikely methods of meeting the need are being explored. It must be admitted that successive governments, having made the career of private builder-owner an impossible one, have done their best to encourage community building under various schemes. These schemes, quite apart from the soundness or otherwise of their finance, have to a very great extent failed to do what they might have done owing to the singularly unhelpful attitude of the building unions, and the large amount of attention now being given to alternative building methods is a natural reaction on the part of society in general to the attitude thus taken up.

As houses are a necessity, if the natural source of supply is checked, artificially or in any other way, the community will automatically turn to alternative sources. It is these causes, and these causes only, which have called forth the proposals and experimental work in connection with steel-sheeted houses, and the work which Lord Weir and others have put forward in connection with this matter have constituted a valuable public service. On the whole the workers in this new field have as yet received few thanks, and the latest pronouncement of any importance in connection with the matter—that of the Technical Committee of the National Housing and Town Planning Council—is more critical than helpful. If out-of-work shipbuilders can produce houses, of which they and other working-class folk are in urgent need, and which the ordinary building trade cannot, or will not, supply, any method of enabling them to do it would appear worthy of encouragement.

The committee suggests that such houses will be damp and that the proposed wood-pulp lining will be likely to become verminous. They are also not convinced that the houses will have an average life of 40 years. These views may be correct, but one has an idea that passenger quarters in large ships are built of steel plates with success, and although a house is not quite the same thing as a ship, there would still appear a good case for further discussion and experiment, particularly in reference to alternative lining methods. The committee makes suggestions in reference to mass concrete construction, but appears to treat the question as though it were more novel than is actually the case. There are plenty of shuttering systems available adapted to house building which have been in operation, on perhaps a small scale, over many years.

NOTES.

State Subsidy to German Shipping and Shipbuilding.

Negotiations have been proceeding for some time between the German Government and German shipowners and shipbuilders in reference to State assistance to the industries they represent. The negotiations have now led to what is considered a satisfactory solution. The aim is quite as much to help the yards to increased employment and to produce a barrier against further unemployment as to assist shipping concerns. The grant is, in fact, officially termed a "productive care for those without employment." The grant has been fixed at 50,000,000 marks per annum, and this sum is available for shipowners for the building of new vessels, subject to the owners themselves finding half of the cost of the new tonnage. The half advanced by the Government is to be lent at 1½ per cent. interest during the time the building proceeds, 4 per cent. for the first year after completion, then 5 and eventually 6 per cent. Providing that the owners are able to find the necessary other 50,000,000 marks, some 400,000 gross tons should be built annually. Reckoning that of these 400,000 tons, half will be required for a 7 per cent. annual renewal of the German merchant marine, then 200,000 tons would represent an annual increase. Forestalling the decision now arrived at, some orders are understood to have been already placed with the yards, presumably to avoid the rise in prices which might be the outcome of the increased employment. The Government, however, has a certain amount of control in this connection and owners, before finally concluding their contracts with the yards, have to submit particulars of their order to the Government department concerned for the purpose of the latter being able to examine prices, &c., so as to ascertain, whether the end in view is being fully achieved.

Bentonite Clay.

Bentonite, first recognised as a peculiar kind of clay in the Fort Benton formation of the Upper Cretaceous in Wyoming about 1898, has since been found to occur in various parts of the United States and Western Canada, and is held responsible for the sticky nature of some prairie soils. It is found in seams up to 10 ft. in thickness, alternating with sandy shales and not infrequently with lignite, and is considered as the residue of volcanic ash which the wind had carried into shallow water. Silica, alumina, and water, in the approximate proportions 61 : 18 : 10, make up 90 per cent. of the dry clay, the rest consisting of iron, lime, alkalis, &c. In water the bentonite may or may not form a stable suspension; that would seem to depend upon the absence or presence of electrolytes; sodium sulphate is almost always observed in bentonite. The crude material is too gritty and impure for direct use; it has to be washed, but then takes up much water so that it must be dried subsequently. A cut cube of dry bentonite immersed in water will, according to Hugh S. Spence (Canada Department of Mines, Paper No. 626) swell to more than 13 times its volume while retaining its cubical shape. Bentonite is, therefore, used as a dehydrating and absorbing agent for water, salts, dyes, and also explosives. It serves also as a pottery glaze and soap clay, an emulsifier for asphalt, tar, &c., an inert filler or loader in paper manufacture and for other goods. It is further used for absorbing the ink of old newspapers, and for the refining of oils and fats commonly effected by means of bauxite, and for cleaning heavy lubricating oils and gasoline; this refining requires a previous treatment of the clay with sulphuric acid. The market for the bentonite is, however, limited. The Department of Scientific and Industrial Research did not find a particular demand for the product in England, and Canada can easily satisfy her demands. But the bentonite water softener should especially be mentioned. For this purpose the clay is granulated, heated to destroy its colloidal character and hydrated again in diluted alkali. In water containing calcium or magnesium salts an ionic base exchange then takes place, the basic ions being taken up while alkali passes into solution; the bentonite is, like Permutit, regenerated in a solution of brine.

The Mersey Road Tunnel.

There are in some parts of the country large industrial and commercial centres separated by wide rivers. In such cases goods have been transported from one side of the river to the other by ferries. Although these means proved adequate to deal with the traffic conditions which formerly existed, the enormous development of road transport, which has been effected in recent years, makes necessary a complete reconsideration of the requirements with a view to making better provision for the future. Now that a Ministry of Transport has been added to the Government Departments and through it grants for the construction of main roads have been made, it has become necessary to study the means of linking these up on each side of large rivers, if full advantage is to be obtained from the improved facilities. The case of the River Mersey is, perhaps, the most important, for it cuts between two centres both steadily increasing in population and extending in industrial importance. For some time now the local authorities have been considering the problem of driving a road tunnel under the river. Because of the national advantage of such a work it is natural that the local bodies should look to the Government for funds for assistance in meeting some part of the great costs involved. Varying success has attended these efforts, but at last it is felt that proposals submitted by the present Administration represent such an improvement over anything formerly proposed, that there is an immediate possibility of framing a parliamentary bill to obtain permission to undertake the work. Meetings have been held, under the chairmanship of Sir Archibald Salvidge, recently, for the purpose of considering the proposals and at one on Monday last in Liverpool, it was decided to recommend the acceptance of the Government offers provided that the grant amounts to 50 per cent. of the capital outlay on the road scheme, and to seek information from the Corporations concerned that the financial details meet their views. The present scheme is that the Government pays 2,375,000*l.*, which is estimated to be half of the cost of the road works, and gives concessions relating to toll-charges which have an estimated capital value of 787,000*l.*, and also in regard to tramway interests which are anticipated to have a value of 400,000*l.*

The Properties and Structure of Quartz.

In his second lecture on the above subject, delivered at the Royal Institution, on Thursday, February 5, Sir W. H. Bragg, F.R.S., described how the dimensions of the space lattice characteristic of the quartz crystal had been determined, in part by measurements of large crystals which gave the ratio between certain dimensions and in part by X-ray analysis which gave absolute values of these. The space lattice was formed by drawing a series of imaginary lines in space through corresponding points of the element of pattern, out of which the crystal was built up. The space occupied by the crystal was thus divided into a series of parallelopipedons, and the volume of each of these was the volume occupied by one unit of pattern. This volume being determined as stated and the specific gravity of quartz being known, the mass of one element of pattern was known and proved to be

three times the mass of one molecule of SiO_2. Hence, the unit of pattern consisted of three molecules of silica. In one respect the results of X-ray analysis showed apparent disaccord with the conclusions reached from a study of the crystal angles. According to the X-rays the height of the element parallel to the principal axis was only one-third as much as ordinary crystallography would suggest, whilst the ratio between the transverse dimensions was the same whether deduced from X-ray studies or from crystal measurements. This indicated, Professor Bragg said, that the three molecules of the unit of pattern were arranged in a helix around a line parallel to the principle axis of the crystal. Such an arrangement would give regular reflection of the X-rays from planes perpendicular to the principal axis, but the molecules would not be equally spaced along other planes, and the X-rays would not, therefore, be regularly reflected. Other considerations, in particular the fact that the plane of polarisation was rotated when polarised light passed through quartz, had long ago led to the belief that the molecules of quartz must have some such helical arrangement. This had been confirmed by Reusch who had shown that if a series of similar plates of mica were superimposed, each successive layer being so placed that the axes of the crystals of one layer made an angle of 120 deg. with the corresponding directions of the crystals in the next layer, this pile of plates possessed the property of rotating the plane of polarisation. Lindemann had since succeeded in getting similar results with short Herzian waves. As was well known a Hertz oscillator produced polarised waves. Lindemann passed these through a box containing balls, which acted as resonators, and he found that when these balls were given the equivalent of a helical arrangement, the plane of polarisation of the waves was rotated by their passage through the box.

The Development of the Motor Ship.

In his presidential address delivered before the Institute of Marine Engineers on Tuesday last, Sir Westcott S. Abell selected for his subject "The Motor Ship in the Light of the History of Marine Propulsion." After a brief review of the historical developments of the past century, he referred to the importance of taking "economic efficiency," or goods carrying capacity per unit cost, as a basis of comparison between different types of vessel, and dealt at some length with the relation between this factor and that of reliability of operation. Figures were quoted to show that in the case of steam-engined ships the reliability had been practically doubted since 1890, and the bearing of this fact on the introduction of new means of propulsion was considered. The development of motor ships was discussed in relation to total tonnage since 1921 and it was mentioned that although in January, 1922, the amount of motor tonnage was quite insignificant, in September, 1924, somewhere about 50 per cent. of all self-propelled vessels under construction were motor driven. From this is was deduced that the final disappearance of the steam engine from overseas trade would be only a matter of time, although the present ratio of the total tonnage of the two types, which is roughly 30 to 1, suggests that it will be many years before such a change can be complete. It is open to question, in view of the possible limitation of the world's oil supplies, whether such an entire change in motive power will ever be completely consummated. The general reliability of the motor ship is shown by the fact that Lloyd's Register of Shipping have recently decided that in the case of this type of vessel, their requirements will be met by a special survey every four years, with a modified examination at each intervening two-year period. A point to which Sir Westcott drew attention, but which is frequently overlooked, is that large savings in fuel consumption do not appreciably affect the general economy of the ship as a whole, as they only influence one item in the cost of running, and can only be justified if they do not impair the maintenance and the reliability of operation. In summing up the present position in relation to engine development Sir Westcott suggested that the principal economic gain arising from the introduction of the Diesel engine had already been attained, and that attention might now most advantageously be devoted to securing the maximum simplicity, gaining thereby in reliability and ease of maintenance.

THE LATE MR. OLIVER HEAVISIDE.

As briefly announced in our last issue, this eminently original thinker on mathematical physics died at Torquay, on February 4. Born in London on May 13, 1850, Mr. Heaviside was in his 75th year at the date of his death. He was temperamentally a recluse and very little is known about his early education and training. He was at one time in the service of the Great Northern Telegraph Company at Newcastle-on-Tyne, but in 1874 retired to Devonshire and devoted himself to the study of the mathematical theory of electricity. As was the case with George Boole, Heaviside's mathematical knowledge seems to have been mainly self-acquired, a procedure which, if difficult and slow, sometimes results in entirely new light being thrown on certain mathematical problems. The student thrown on his own resources may originate new methods of attack, and thus it was with Heaviside. Heaviside also resembled Boole in his reliance on, and skill in, the use of symbolic methods.

He was probably much greater as a philosopher than as an expositor, and the late Professor Perry did good service in explaining more clearly some of Heaviside's methods, and particularly his development of the idea of fractional differentiations and integrations. Everyone knows what is meant by $\frac{dy}{dx}$ or by $\frac{d^2y}{dx^2}$, but Heaviside succeeded in attaching a meaning to such expressions as $\left(\frac{d}{dx}\right)^{\frac{1}{2}} y$, and thus arrived very simply, at certain results hitherto only reached by a more complicated analysis. It was by making use of this method that Professor Perry made the first serious attack on Lord Kelvin's figure for the age of the earth. The latter is, of course, now completely discredited, but for reasons other than those advanced by Professor Perry. It seems probable that Heaviside's mathematical methods, may be largely employed in the future. One, possibly sanguine, mathematician has expressed in conversation, the opinion that his "operators" will, by providing more direct methods of obtaining the required arithmetical results, render unnecessary the solution of equations in series of spherical harmonics. This consummation is one undoubtedly to be wished, but sounds too good to be true. The Royal Society did publish one paper by Heaviside on this subject, but a second has merely been stored in the archives, the reason being, it is understood, that certain portions were in conflict with well-established results. It seems probable, however, that some part at least of any paper by so original a thinker must be valuable, and it would be well if this could be sorted out and published. Possibly, some Lord Rayleigh of 40 years hence will do the same for Heaviside as the late Lord Rayleigh did for Waterston, whose paper on the kinetic theory of gases, submitted to the Royal Society in 1845 was not published till some 40 years later, after other investigators had independently arrived at the most important of the author's conclusions.

At the worst though, Heaviside was more fortunate than Waterston. The value of his work was recognised long before his death. He was one of the first to show that a moving electric charge possessed inertia, a fact which is all important to the modern doctrine of relativity. He discovered and filled in a gap in Lord Kelvin's theory of signalling through a submarine cable, and pointed out that induction should improve telephonic transmission. This contention was strongly combatted by the Post Office, who professed moreover to have proved its worthlessness by certain experiments they made at Newcastle. In America, however, the idea was taken up by Professor Pupin, who naturally found the Western Union more open to new ideas than our Post Office. With their encouragement and assistance, Professor Pupin, practicalised Heaviside's theory, and "loaded" cables are now employed not only for submarine telephony, but also on certain long-distance land lines.

Heaviside is also recognised as having played a leading part in providing an intelligible explanation of the ability of wireless waves to pass round a large fraction of the earth's circumference, instead of proceeding straight out into space. He showed that it was probable that a conducting layer (now known as the Heaviside layer) would be formed by the ionisation of the molecules in the upper regions of the air. Such a conducting layer would act as a reflector, so that the wireless waves are confined between this and a second conducting layer formed by the surface of the sea. The working out of this view of the curvilinear propagation of wireless waves has been largely due to Dr. Eccles.

Owing to his peculiarities of temperament, Heaviside took little part in discussions at scientific or technical societies. He was elected F.R.S. in 1891, and when the Faraday Medal of the Institution of Electrical Engineers was founded in 1922, the Institution honoured itself in making the first award to Heaviside. He published two volumes of "Electrical Papers" in 1892, and his three volumes on "Electro-magnetic Theory" were reprinted in 1922. It is interesting to add that his "operators" are now being carefully studied by certain mathematicians abroad.

The Patent Office Library.—A new Subject List of Periodical Publications kept in the Patent Office Library has been prepared and is obtainable from the Patent Office at the price of 2*s*. The publications dealt with include journals, transactions of societies, year books, reports of permanent congresses and of State and municipal departments, the titles being listed under subject headings arranged alphabetically.

The Fusion Retort for Low-Temperature Carbonisation.—With respect to our Note under the above title on Mr. Stainer Hutchins' paper on "Low-Temperature Treatment of Bituminous Materials" [ENGINEERING, January 23, page 112 *ante*]. Mr. Stainer Hutchins asks us to point out that there is no central shaft in the fusion plant. We thought that this had been made clear. Our words were: "Baffle agitators, fixed to a longitudinal shaft or riding on it, were not, of course, new. But Mr. Hutchins divides his agitators into several independent sections which are placed loosely in the retort so as to keep falling over." The loose agitators tumble over as the retort tube revolves. We did not question the novelty of this arrangement, for which Mr. Hutchins has secured patent protection, and we willingly accentuate the point.

Manchester Association of Engineers.—At the annual dinner of the Manchester Association of Engineers which was held in the Midland Hotel, Manchester, on Tuesday last, the Lord Mayor of Manchester, Alderman West, suggested the necessity for greater interest in local affairs on the part of engineers. Cheap light, heat and power, efficient public transport schemes, well paved and well cleaned streets, adequate water supply, and the efficient disposal of sewage were all essential to the well-being of a city, and the people who were familiar with these matters had a duty to perform on behalf of the community. Mr. Herbert Bates, the president, replying on behalf of the Association, said that one of the greatest obstacles to the return to normal trade conditions was the excessive burden of taxation. Means must be found to reduce freights, imperial and local taxation and the cost of living to enable the manufacturer to offer his goods at prices which would attract business.

The Motor Vessel "Clydebank."—Another of the fleet of motor ships being built by Harland and Wolff, Limited, of Govan, for Messrs. Andrew Weir and Co., of the Bank Line, Limited, the Clydebank, was recently delivered to her owners after undergoing successful trials. She is a twin-screw vessel of the shelter-deck type, 434 ft. long, 53¾ ft. broad, and 37 ft. deep, having a gross tonnage of about 5,200. There are two complete steel decks in addition to the boat deck, captain's deck and navigating bridge. Seven bulkheads extending to the upper deck divide the boat into five cargo holds, motor-room, and fore and aft peaks. One hold is designed for use either as a deep tank or for the carriage of ordinary or oil cargo, as required. A double bottom provides space for the carriage of water or oil fuel. The propelling machinery of the Clydebank consists of two sets of six-cylinder Harland-Burmeister and Wain oil engines with electrically-driven auxiliaries. Twelve derricks, specially constructed by the builders and each capable of handling a load of 5 tons, are provided for operating the hatches and handling cargo. In addition, a derrick is fitted at the after side of the foremast for handling lifts up to 25 tons. The cargo winches are steam driven. Telemotor control is adopted, the steering gear being electrically driven.

LETTERS TO THE EDITOR.

THE THERMAL EFFICIENCY OF POWER STATIONS.

To the Editor of Engineering.

Sir,—I have read with great interest the article by Mr. R. H. Parsons in your issue of January 23 (page 93, *ante*), in which he attempts to evaluate the degree of accuracy to be obtained in the analysis of coal.

The sampling of coal, in order to obtain a truly representative sample for analysis, presents considerable difficulty, and requires extreme care. Even when every precaution is taken, it is probable that errors in sampling exceed those of analysis, but it is upon the latter that I wish to offer a few remarks.

The determination of the ash content of fuel is straightforward, and, as Mr. Parsons remarks, "should be determinable with as much precision as the chemical balance is capable of." This is indeed the case, and the conclusion that "the distribution of ash through coal is so erratic that the proportion even in two portions of a crushed and carefully mixed sample may vary widely" is not, in my experience, justified. Either Mr. Parsons has been unfortunate in his analysis, or the sample has been badly prepared and mixed. The latter is probably the case. With well mixed finely ground samples duplicate determinations rarely differ by 0·1 per cent.

The case of volatile matter is somewhat different. In order to obtain consistent results the experimental conditions of the determination must be strictly defined and rigidly adhered to. Except when carried out by skilled operators of long experience, I believe the method recommended in the interim report of the Fuel Research Board, is very likely to give inconsistent results, and I much prefer the method adopted in this laboratory, in which the coal is heated in an electric muffle maintained at a definite temperature for a definite time. These conditions are easily regulated with great precision.

The accuracy of the determination of ash and volatile, however, does not affect that of the calorific value of the fuel, which is determined independently, and is the essential thing required in calculating the thermal efficiency of either a boiler house or of a power plant as a whole.

For the determination of calorific value Mr. Parsons assumes, as indeed is often the case, that previously dried fuel is burned in the calorimeter, so that a determination of moisture is necessary, since from this is calculated the calorific value "as fired." Considerable importance, however, attaches to the determination of this moisture content, and it is not generally realised that not only may moisture be lost from the prepared sample if it is unnecessarily exposed to the air before drying, but also that unless the time and temperature of drying are most rigidly controlled, chemical changes can take place in the coal, which affect the subsequently determined calorific value in a varying and considerable degree.

These chemical changes consist in the oxidation of the coal; and also, most probably, in the loss of small amounts of light volatile matter rich in hydrogen and hence, of high calorific value. The drying of a sample of finely divided coal will thus lead to a diminution in its calorific value to an extent dependent, not only upon the conditions of drying, but also upon the constitution of the coal. It is impossible to correct for this error, as it varies with almost every fuel, but while it is possible to avoid it to a great extent by keeping the drying temperature down to 105 deg. as a maximum, and limiting the time of drying as much as possible—usually one hour is necessary—I very much prefer firing the "wet fuel as received," in the calorimeter. This method has been adopted in the laboratories of Electro Bleach and By-Products, Limited, and it avoids all the above-mentioned errors due to drying.

Some time ago a series of experiments was carried out here, using a Berthelot-Mahler Bomb. The calorific value of various fuels was determined "as received," and then after various periods of drying at 103 deg. C.

The values obtained from the dried fuels calculated back to "as fired" by allowing for moisture determined at 103 deg. for a minimum period, were almost invariably lower than that obtained by firing the wet fuel directly, while the calorific value of the dried fuel decreased with time of drying at 103 deg. C. After an initial loss in weight due to loss of moisture at 103 deg. C., the sample being dried invariably increased in weight, due no doubt to oxidation. This is well illustrated by the set of figures given below.

It will be noted that the calorific value calculated from the determination on the dried fuel never reached the value obtained by actually burning wet fuel, and this has been confirmed with several different coals, although the amount of divergence varies with the nature of the fuel.

In comparing results determined here and in the laboratory of an associated firm good agreement has almost invariably been obtained when the "wet fuel as received" has been burnt in the calorimeter. On the other hand when the method adopted has consisted in burning dried fuel and calculating back to "fuel as fired" by means of the moisture test, differences have often occurred.

Analyses of Wet Fuel as Received.

Calorific value = 12,550 B.Th.U.
Moisture = 2·8 per cent.

From these figures, the calculated calorific value of the dried fuel would be 12,911.

Treatment.	Calculated Value with Bomb.	Per Cent. Total Loss in Weight of Dried Sample	Calculated "Higher Calorific Value."
Wet coal containing 2·8 per cent. moisture ..	12,550	2·80	—
After 1 hour at 103 deg. C.	12,705	2·80	12,352
After 2 hours at 103 deg. C.	12,775	2·80	12,418
After 3 hours at 103 deg. C.	—	2·70	—
After 5 hours at 103 deg. C.	—	2·54	—
After 7 hours at 103 deg. C.	12,700	2·22	12,420
After 24 hours at 103 deg. C.	12,500	2·02	12,247

As regards the degree of accuracy to be obtained with the bomb calorimeter, the experience in this laboratory is that the degree of accuracy suggested by the Fuel Research Board—namely, 30 B.Th.U. between two tests on the same sample—can usually be obtained by careful observance of temperature conditions and details of manipulation. A difference of as much as 60 B.Th.U. on a 12,000 B.Th.U. coal is unusual and calls for a further check test.

If I may summarise the above statements I believe that satisfactory and consistent determinations of calorific value can most readily be made on the "wet coal as received," and that the wide variations quoted by Mr. Parsons are at least in part due to the practice of making the determinations on dried fuel and calculating back. The moisture in industrial coal is rarely sufficient to prevent good combustion in the calorimeter, and I suggest that if the practice of burning "wet coal as received" in the bomb be generally adopted, it will be much easier to make accurate comparisons between the heating value of various fuels, and hence, between the thermal efficiencies obtained from them in various plants.

Yours faithfully,
A. C. Dunningham, D.Sc.,
Chief Chemist Electro Bleach and By-Products, Limited
Middlewich, Cheshire.
February 5, 1925.

BRITISH MACHINE TOOLS AT EXHIBITIONS.

To the Editor of Engineering.

Sir,—It is now certain that, unless present arrangements are altered soon, the great British machine tool industry will be, as in 1924, practically without representation by exhibits at the forthcoming British Empire Exhibition. The Exhibition of 1924 contained examples of several industries in which this country holds an almost undisputed lead, but the machine tool industry, which has to meet keen foreign competition, was hardly represented at all.

Ten to twenty years ago there was but little difficulty in naming many types of foreign machine tools and appliances which were generally considered to be superior to anything of a corresponding model built in this country.

Owing, however, to the enterprise and skill of British machine-tool designers and makers, the home products in nearly every instance now equal, and in not a few surpass, those from overseas. But the general opinion as to the superiority of certain foreign tools has been formed slowly, not only in this country, but also in others which had hitherto been good markets for British machine tools, and this opinion is in consequence all the more firmly established. Hence, it is clearly of the greatest importance for the prosperity of the industry to be able to prove to all users of machine tools that British makers have recovered lost ground.

Now, the Wembley Exhibition of 1924 provided a much-needed and invaluable opportunity for showing the excellence of British products to all interested and instructed visitors, and especially to those from abroad. But only two or three firms exhibited, while the others were content to be represented by a small office in the Palace of Engineering, which contained photographs of machine tools.

Several arguments have been advanced in support of the attitude taken by the machine tool industry towards the Empire Exhibition. For example, it was pointed out that an exhibit of machine tools, if it is to be really effectual, must be in operation under power, and that the total cost of power, attendants, &c., for six months would be a very heavy charge on the industry. But it is noticeable that machine tools at exhibitions are not generally in operation at full power for any considerable time in aggregate, or if they are, then it is on some remunerative work.

It was also urged that the industry had already made all arrangements to hold an exhibition of their own in the autumn of 1924 (this, of course, took place at Olympia and occupied about three weeks). But it is necessary to bear in mind that it had been known for a considerable time beforehand that the British Empire Exhibition would be held from April to October of 1924. And the latter, on account of both its importance and duration, obviously furnished opportunities for effectual publicity much exceeding those of the exhibition at Olympia.

Yours faithfully,
T. W. MacAlpine.
Finchley, London, N. 3,
February 3, 1925.

BOILER TESTS.

To the Editor of Engineering.

Sir,—With regard to the letter of Mr. W. M. Hebblethwaite under the above heading, published in Engineering of January 23, 1925, I think it may be useful to call attention to the following points:—

1. Mr. Hebblethwaite suggests that the results of a test lasting 5 hours 50 minutes do not after all amount to much, because of its brief duration. No doubt there would be something in this criticism if the test stood alone, but as it is one of a series averaging about 84 per cent., the results of which are fairly in accordance with that published, it serves no useful purpose to consider the matter further, except that I find the difference in efficiency between testing and average running conditions to be approximately 5 per cent., which in the case of the test under review agrees with our average boiler house efficiency of 79 per cent.

It will be appreciated that the difference between long and short tests will vary with the method of operation, load factor, class of coal used, &c., but the most important factor governing prolonged high efficiency depends on the cleanliness of the heating surface, both internally and externally, which in our case is admirably maintained by correct feed water treatment and suitable soot blowing apparatus.

2. With regard to the second paragraph of Mr. Hebblethwaite's letter, I am quite unable to agree with his contention that the cost of evaporation based on actual water evaporated per lb. of coal is more accurate; as a matter of fact it is the reverse. The amount of heat realised from the combustion of 1 lb. of fuel is directly proportional to boiler efficiency. Take, for example, two boilers using the same coal and giving identical efficiency, but factors of evaporation 1·28 and 1·35, the actual evaporation per lb. of coal is 7·74 and 7·33 respectively.

Would Mr. Hebblethwaite use the actual basis or the "from and at 212 deg. F." for comparison? The cost of evaporation per 1,000 gallons is virtually the same in each case, but not if worked on actual water evaporated. Assuming coal of 12,000 B.Th.U. at 18*s.* 6*d.* per ton the latter method gives 10*s.* 8*d.* and 11*s.* 3*d.* respectively, while on the "from and at 212 deg. F." basis 9*s.* 4*d.* is obtained in both cases.

3. Referring to Mr. Hebblethwaite's statement of the fuel cost per 10,000 lb. in his own Stirling boiler, I may congratulate him on his favourable figure, but it must always be remembered that this figure of coal cost per 10,000 lb. is dependent upon a large number of factors, including the question of fuel cost which may be and is very variable as from one boiler house to another.

This factor has nothing to do with boiler efficiency, but may in some cases produce a favourable cost figure, even with comparatively low efficiency, and consequently it is not possible to judge the relative methods of the working of two stations merely from this figure without further data.

Yours faithfully,
S. E. Fedden, General Manager, Electric Supply Department.
Sheffield, February 4, 1925.

THE WHITWORTH SCHOLARSHIPS.

To the Editor of Engineering.

Sir,—I shall be pleased if you will allow me to make a short comment on the second letter of "Not a B.Sc." This letter explains completely the reason for the bitter attack embodied in its predecessor, and also to some extent qualifies it. I realise the shortcomings of the present educational system as well as any one, and certainly I do not regard the curriculum mentioned as the climax of scientific attainment! On the contrary, my experience has been that the

best training obtainable can only put in the general outlines of engineering, and therefore it forms the foundation for future work. I still maintain that the groundwork for the Whitworth scholarships or the honours degree in engineering provides a broad basis upon which to specialise, and that the young engineer who has covered this groundwork has put in some useful work which will serve him in good stead in his career. All the cases cited by "Not a B.Sc." could be offset by many cases to prove the value of a degree or a Whitworth scholarship as an indicator of talent.

The patchwork nature of the technical training received by your correspondent occasions no surprise because the education of an engineer occupies a lifetime. How, then, can the training be completed in, say, four or five evening sessions at a technical college? A large amount of accumulated experience must of necessity be omitted. I had to fill the gaps just as "Not a B.Sc." and others have had to do, but I am grateful to my instructors for their guidance. If one learns how to study, then something has been achieved.

Evidently "Not a B.Sc." was as ambitious as anyone and believed what he condemns in others—namely, that, having passed through the college, he had attained a passport to a progressive post. He says he would want something in addition to a diploma when choosing his engineer—meaning, of course, ability.

Men of proved ability are generally relatively well paid by the firms who are fortunate enough to possess them, and therefore these men are not often in the market. Recourse must be had to young untried talent, and some indication of the very necessary scientific training is therefore required. A degree or diploma serves as evidence that this training has been given, and if these are not acceptable, then a test to suit the occasion would be needed.

I could not allow the first letter to pass without some criticism, because it tended to do incalculable harm amongst the student-apprentices in the engineering profession, and the object of my first letter has been attained and is evident in the explanation contained in "Not a B.Sc.'s" second communication. I am grateful to him for taking the trouble to write out his ideas more fully, because others would read into his original statements exactly what I, and, apparently, "Interested" read therein.

Yours truly,
H. H. W.

Wigan, February 2, 1925.

WATERLOO BRIDGE.

TO THE EDITOR OF ENGINEERING.

SIR,—I am curious to know how the letter from the Council of the Institution of Civil Engineers to a Committee of the L.C.C. (see ENGINEERING, January 23, page 116) is interpreted by those of your readers who are interested. What the intention of the Council may have been might perhaps be ascertained by direct inquiry, but it seems to have been understood by the L.C.C. Committee as confirming expert opinions then before them, and that is the way in which it is interpreted by myself.

Is that or is it not, a reasonable understanding of the letter? It is a matter of some importance, as upon this appears to turn in a measure the fate of Waterloo Bridge. The procedure on the part of the L.C.C. has been somewhat unusual, and I am wondering what would have happened if this body, having sought the opinion of eminent K.C.'s on a legal point, had later submitted that opinion to the General Council of the Bar for further consideration.

Yours faithfully,
W. H. THORPE.

12, Buckingham-street, Strand, W.C. 2,
February 9, 1925.

LABOUR NOTES.

REPRESENTATIVES of the Engineering and Allied Employers National Federation and the engineering trade unions further discussed the wages question at conferences in London on February 10 and 11. The unions desired an increase of 20s. per week, but were apparently agreeable to take less. They pressed the employers to make a definite offer. The following proposal was submitted by the employers to the unions:—

"The employers, being of opinion that the present state and prospects of industry do not warrant any increase in the load of production costs, but, being willing to meet as far as possible the claim of the unions for advance, and being anxious to arrive at an amicable settlement, and so foster the industry, feel that they are not warranted in deciding the amount of advance to be given unless and until the unions have demonstrated the extent to which they are prepared to modify existing working conditions, and thus avoid damaging the prospects of the industry at this extremely critical stage. The employers repeat the offer already made to proceed with negotiations on the foregoing basis."

The unions replied as follows:—"The unions' representatives intimate to the employers that they regret the attitude adopted by them in attempting to force upon the trades as a condition of offering an advance in wages, matters involving existing working conditions which have been subject of separate negotiations and upon which the unions' representatives have no mandate, and unless the employers are prepared to make an offer of a definite amount they have no alternative but to report the present position to their respective executives."

To that the employers made the following reply:—"The employers regret that their expression of willingness, notwithstanding the present position and prospects of the industry, to meet the situation should have failed to evoke correspondingly effective response from the unions who equally with the employers are interested in the prosperity of the industry. The employers are still prepared to continue the negotiations on the basis they have proposed, and they await the result of consideration of the position by the executives of the unions."

The decisions of the executives are to be communicated to another meeting of the joint committee of the trade unions on March 4, and a further conference with the employers will, no doubt, be asked for.

As was expected, the executive of the National Union of Railwaymen at a meeting in London on February 7 decided to make use of the conciliation machinery provided by the Railways Act, 1921, for the settlement of disputes. They will submit the proposals contained in their national all-grades programme to the Central Wages Board in the first instance, and failing a settlement there, the demands will automatically go to the National Wages Board. The position is complicated however, by a further decision of the executive not to accept any settlement which does not apply to all the grades included in the programme. The shopmen and power-house men, amongst others, are outside what are known as the conciliation grades. At the conclusion of Saturday's meeting the following official statement was issued:—"The Executive have considered the refusal of the railway companies to entertain the proposals contained in the national programme, and they have decided to refer the whole of the programme to the Central Wages Board, with a request for an early meeting to discuss it. In the event of the companies refusing to allow the machinery to function on behalf of those grades outside what are known as the conciliation grades and the salaried staff, a further meeting of the Executive will be held to consider what action shall be taken to give effect to the proposals contained in the programme. With regard to the companies' counter-proposals for reductions, the Executive have not only decided to oppose them, but, as indicated in their previous decision, to use the full force of the union with a view to an improvement in the railwaymen's conditions by whatever machinery can be utilised to that end."

The counter-proposals of the railway managers to the N.U.R. national demand were also formally communicated to the Associated Society of Locomotive Engineers and Firemen, with a request for a conference to discuss them. At a meeting on Saturday the executive of the trade union decided to oppose the companies demands. A conference with the railway managers has been fixed for Monday. The A.S.L.E.F. has not identified itself with the N.U.R. application, but, it is stated, that when its representatives meet the railway managers they may decide to put in a claim for increased wages for drivers, firemen and cleaners. The Railway Clerks Association has already decided to refer the matter to the Wages Boards, so that the whole issue, as it affects all the companies and all the unions, is practically certain now to be dealt with in that way.

The British proposal of an unconditional and informal conference on trade union unity with the All-Russian Congress of Trade Unions has, not unexpectedly, been rejected by the Council of the International Federation of Trade Unions. In its place, the following resolution, moved by M. Stenhuis (Holland) and seconded by M. Smit (Clerical Workers' International), has been carried by 14 votes to five:—

"The General Council of the International Federation of Trade Unions, having examined the correspondence between the I.F.T.U. and the All-Russian Council of Trade Unions, instructs the Executive Committee of the I.F.T.U. to inform the All-Russian Council of Trade Unions that the I.F.T.U. is prepared to admit the All-Russian Federation of Trade Unions, when they express their desire to this effect. The I.F.T.U. also declares itself prepared to convene a conference in Amsterdam with the All-Russian Council of Trade Unions with a view to an exchange of opinions as soon as possible after the All-Russian Council of Trade Unions intimates its desire to be admitted to the I.F.T.U."

The following Committee was appointed to act in the matter for the Amsterdam International:—Messrs. A. A. Purcell (chairman), Fred Bramley (Britain), L. Jouhaux (France), C. Mertens (Belgium), T. Leipart (Germany), Grassmann (Germany), Zulawski (Poland), E. Fimmen (International Transport Workers' Federation), and the three secretaries—Messrs. J. Oudegeest, J. Sassenbach, and J. W. Brown.

The resolution has been variously interpreted since its adoption, some representative trade unionists regarding it as an admirable compromise and others claiming that it effectively excludes the Russian organisation. Obviously, however, a great deal depends on the line which the Russians select to take before and at the proposed conference. If they decide to accept the constitution of the Amsterdam International, and in that way dissociate themselves from the Red International, they will be allowed to affiliate. On the other hand, if they decline to do so, and seek to impose the constitution of the Red International on the Amsterdam International—which has been their avowed aim all along—their application for affiliation will be rejected, as in most of the smaller Continental countries, the opposition to Moscow is extremely bitter. The general feeling in International Labour circles appears to be that no more is now likely to be heard of the proposed Russo-British Committee to promote world trade union unity.

The following statement has been issued by the National Allied Building Trades Employers:—

"The action of the bricklayers', masons', and plasterers' unions in threatening to withdraw from their own national federation and in giving notice to withdraw from the National Wages and Conditions Council of the building industry shows that they are deliberately clearing their decks for action. As they are by agreement committed with other members of the National Federation of Building Trade Operatives to a stabilisation of wages to February, 1926, it is difficult to see any reason for their action, unless it be that by remaining in these respective bodies they cannot obtain preferential treatment over their fellow-workmen in the building industry. Therefore, are they getting outside in order to place themselves in a position to exploit the present scarcity of the crafts? If such an exploitation would mean that the Government, the housing authorities, and the public would find the costs of building seriously increased they must be prepared to decide whether they will tolerate such unnecessary expenditure. The 'trowel group' of craftsmen consistently fluctuated in its attitude towards housing during the passage of the Wheatley Bill through Parliament. Apparently the members are only prepared to work for the common good when they can wring some new economic advantage out of the employers, and, therefore, ultimately, out of the pockets of the public needing houses. The employers, in their determination to resist unconstitutional action, are not decrying organisation of their employees. In fact, they prefer complete organisation on both sides of the negotiating table. But they maintain that industrial organisations can only justify themselves as instruments of negotiations when they honour the signatures of their representatives both in the spirit and in the letter."

The Supreme Economic Council of Soviet Russia has passed a resolution expressing the opinion that (1) encouragement should be given to the engagement of trained engineers from other countries; (2) young Russian engineers and technical workers should be sent abroad for a course of practical training.

Details of the economic position of the Union of Soviet Socialist Republics in December last are given in the *Soviet Union Review*. Of the productivity of labour, it is stated that, taking into account the fact that the number of workers employed has only increased by 0·4 per cent., whereas gross output in most industries has increased by 12 to 15 per cent., there can be little doubt that there has been an appreciable increase in the productivity of labour during December. The total wages bill in November fell by 9·5 per cent., as compared with October, owing to the smaller number of working days, but the wages per day show an average increase of 2·7 per cent. It is estimated that the wages for December have increased by 9 to 10 per cent. and that there has also been a rise in the average daily wage.

One of the resolutions which the National Minority Movement is endeavouring to induce trade union branches to pass and send up for submission to the next Trade Union Congress, relates to Factory Committees. It is as follows:—

"That this Trades Union Congress is of the opinion

that the time has arrived for the creation of a single front of the workers in each industry against the strongly-organised employing class, and asserts its belief in the value of Factory Committees which will concern themselves with non-unionism, engagement and discharge of workers, workshop grievances, &c., as a step to this end. It believes that the unity of the workers in the workshops, independent of their trade or calling, is a necessary preliminary to real unity through amalgamation, and, therefore, instructs the General Council to approach the executives of the affiliated unions with a view to undertaking a campaign for the establishment of Factory and Workshop Committees."

An "explanation" of the proposed resolution by one of the National Minority Movement's prominent men appeared in a recent issue of the *Worker*. In the course of the article, the writer says :—

"To function properly, these Factory Committees must be possessed of, and thoroughly permeated with, the spirit and purpose of the class struggle. Their activities must be carried on in direct antagonism to the employers and the capitalist class generally. They must consistently refrain from becoming entangled in any employers' schemes of co-partnership and profit-sharing. They must be quick to seize on any trouble or complaint, any workshop grievance, to bring before the employer and demand redress. They must be the leading organs in the working class movement for initiating wages' and hours' struggles and movements for improving working conditions."

According to the same organ of extremism, another of the Minority Movement's prominent men told a meeting that the old ideas of craft and sectional unionism must be abolished. The workshop must be made, he said, the basis of our future industrial organisation irrespective of craft or occupation. The limited conceptions of trade unionism must be swept aside. Interest must be stimulated in the question of workers' control of industry. After the Revolution, the trade unions would be compelled to play a vital part, and in order to prepare for the overthrow of capitalism, they must be transformed from sick and benefit societies into real organs of the class struggle, playing an immediate part in the fight for the realisation of the workers' immediate demands, but all the time showing the workers that their real problem was the conquest of power and the establishment of Socialism. By "Socialism," the speaker, no doubt, meant "Communism."

The Ministry of Labour states that on February 2, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,237,900, *viz.*, 935,300 men, 37,000 boys, 231,000 women, and 34,600 girls. On January 26, 1925, the number was 1,240,922—935,495 men, 37,778 boys, 231,678 women, and 35,971 girls—and on February 4, 1924, it was 1,248,475, made up of 923,133 men, 40,908 boys, 244,660 women, and 39,774 girls.

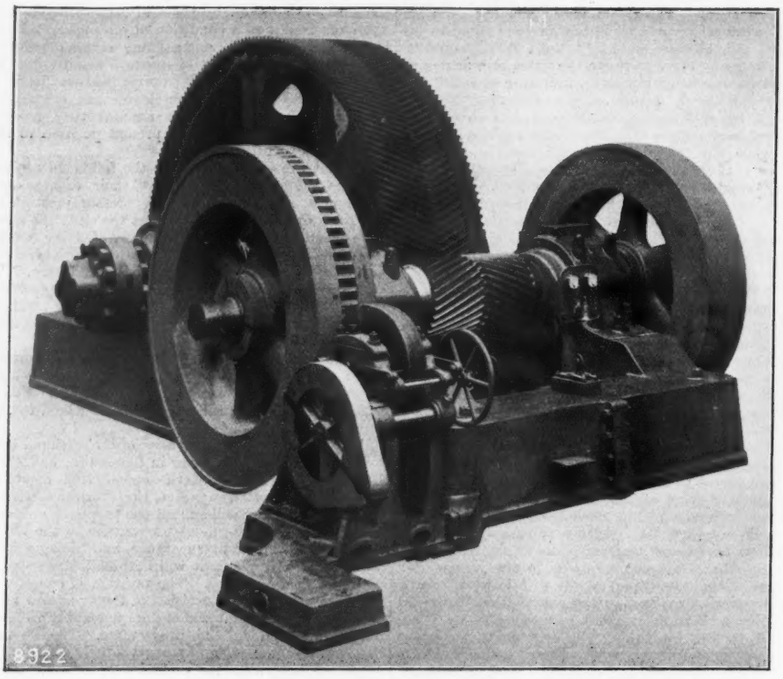
In the course of a lecture on "Industrial Fatigue," delivered at East London College on February 9, Professor C. S. Myers said that an important cause of industrial fatigue arose from the employment of inexpert workers. Too often their inexpertness was due to lack of systematic training in the best methods of work. They were found to use considerably more effort than the more expert workers, and hence to tire far more rapidly. Their inefficiency might be also due to a natural unfitness for the particular occupation in which they were engaged. In order to choose more successfully the "square peg" for the "square hole," vocational selection tests were being introduced into various industries. Vocational misfits suffered from boredom, and were a prime cause of industrial unrest, generating within the factory an atmosphere of contagious dissatisfaction.

Personal.—It is announced that Messrs. Richard Lloyd and Co., Limited, of Steelhouse-lane, Birmingham, have acquired the goodwill, patterns, etc., of Messrs. Stockton and Bunn, Limited, of 11, Queen Victoria-street, London, E.C.4, and will carry on the business in small tools, &c., at that address.

The Closing of Finsbury College.—As is known, the London County Council has determined to close the Finsbury Technical College in 1926, owing to insufficient financial support from the City Companies. In taking this step, the Council appears to have overlooked the desirability of making provision for the subsequent employment of the staff of the College. In view of this, the National Union of Scientific Workers, at the annual Council meeting, held on January 31, passed a resolution urging the London County Council to make arrangements "for the absorption in other institutions, with seniority, of those members of the staff who will be on the staff when the College closes." The resolution has been forwarded to the Chairman of the London County Council Education Committee.

GEAR DRIVE FOR SHEET ROLLS.

MESSRS. SCOTT AND HODGSON, LIMITED, GUIDE BRIDGE, MANCHESTER.



GEAR DRIVE FOR SHEET-ROLLING MILLS.

A common arrangement in sheet-rolling mills is to drive by means of ropes from an electric motor. While this has proved to be a reliable way of working, it has the obvious disadvantage of taking up a great amount of space. If a compact drive is required, the use of gearing satisfies this condition and enables the speed requirements to be obtained, while it permits the use of flywheels as a means of storage of kinetic energy, which can be made available for dealing with peak loads. When these flywheels are mounted on the high-speed or pinion shaft of the gearing they need not be of great weight to obtain a large storage of energy. Such an installation of gearing and flywheels is shown in the accompanying illustration, which depicts an equipment recently built by Messrs. Scott and Hodgson, Limited, of Guide Bridge, near Manchester. This is one of two sets, each of which will be used to drive eight hot-sheet mills with 30-in. rolls. In this plant the gears are amongst the largest of their type ever built in this country and were made by the Power Plant Company, Limited, of West Drayton. The wheel is 16 ft. 7 in. pitch circle diameter and 4 ft. wide. It was designed to transmit frequent peak loads of 10,000 h.p. at 34 r.p.m. of the mill shaft, but 15,000 h.p. may be transmitted safely by it as a momentary peak load. As actually installed each of the two units will be driven by an electric motor of 2,000 brake horse-power normal rating and 5,000 brake horse-power peak-load capacity at 245 r.p.m. One of the motors for the purpose was constructed by the English Electric Company, Limited, of Queen's House, Kingsway, London, and the other by the Metropolitan-Vickers Electrical Company, Limited, of Trafford Park, Manchester. It is apparent that there is ample reserve capacity in the gearing for possible future extensions.

The bedplate of the gear extends completely round the gears, and all the joints in it and seats for the pedestals are carefully machined. From the electric motor the drive is taken through a Wellman-Bibby coupling to the pinion shaft, on each end of which there are flywheels of 16 tons weight. These are made with splits cast in the boss to reduce contraction stresses, and are fitted with strong steel hoops shrunk on them. One of these flywheels has teeth cut in the middle of the rim for use in barring operations. Ample support is obtained by the use of self-aligning bearings with steps which have spherical seatings. These bearings are 16 in. diameter and 32 in. long, and are lined with anti-friction white metal. The pinion is, like the wheel, of 4-ft. width of face. It has a pitch-circle diameter of 28 in. and is forged solid with the shaft. The teeth of this pinion gear with those of the wheel, which is of 16 ft. 7 in. pitch-circle diameter. The diametral pitch of the teeth is unity. The large wheel is made of steel in halves, which are secured together by hoops at the boss and bolts at the rim. The pedestals for the wheel are fitted with bearings 24 in. diameter and 32 in. long, which are also lined with anti-friction white metal. At the ends of the main shaft there are half-couplings forged solid with it. Similar cast-steel half-couplings are associated with these, are provided with driving keys and turned-steel bolts, and have wobblers cast on them to carry the drive to the mills.

The barring gear is operated by a 50 brake horse-power electric motor which runs at 575 r.p.m. and gives a speed of $\frac{7}{8}$ r.p.m. to the rolls. This is obtained through double-reduction steel spur gears. The driving pinion is mounted on a well-supported spindle and gears with the teeth cut in the face of one of the flywheels. It is so arranged that disengagement takes place automatically when the main drive is started up. The gears are enclosed in an oil-tight casing made in sections, built up of sheet steel and angles welded together. For inspection and cleaning, doors are provided in suitable places in this casing. For lubrication purposes oil is sprayed on the face of the gears by an oil pump of the gear-wheel type. In the bearings of the pinion shaft the Scott and Hodgson high-pressure film system of lubrication is used. In this, oil at pressures up to 150 lb. per square inch is introduced below the shaft and effects a complete mechanical separation of the rubbing surfaces. Continuous circulation of the oil for this purpose is obtained by the use of pumps. The central-pump system, which comprises five separate units mounted in a large cast-iron tank placed below the floor level, also supplies oil to the bearings of the main shaft. The drive for the pumps is obtained from the end of the high-speed shaft by belting, and they are fed with oil from two separate compartments of the tank, so that suitable qualities of oil may be used for the bearings and for the gear sprays. Flow indicators and pressure gauges, mounted on a pillar on the bedplate, enable the conditions operating in the lubrication system to be detected instantly.

Committee of Scientific and Industrial Research.—We are informed that Dr. Jeans, F.R.S., secretary of the Royal Society, and Sir William Ellis, have been appointed members of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

ROLLER EXTENSOMETERS FOR LONGITUDINAL AND LATERAL STRAINS.

IN a former issue of ENGINEERING (vol. cxiii., page 684), a small extensometer, developed by Professor E. H. Lamb was described, in which the relative movements of two pairs of points in the length of a test-piece were imparted to a pair of rollers held between plane parallel surfaces and each carrying a plane mirror, the sum of the rotations of the two rollers being observed by means of a telescope and scale. The instrument referred to was made for a gauge length of 1 in., and as the idea worked out well in practice and was accurate in operation, it has since been developed and adapted for a variety of gauge lengths. The "idle rollers" of the original design have since been replaced by steel balls, and a number of other improvements have been introduced which have added appreciably to convenience in operation. One of the later models, shown in Fig. 1, for a gauge length of 8 in., has rollers of 0·25-in. diameter, the instrument being of correspondingly robust construction. With a scale distance of only 2 metres it is easily possible, with this instrument, to measure accurately the elastic stretch of a steel rod when stressed to about 5 tons per square inch, within 0·5 per cent.

In addition to the special features of the instrument which have been previously described, such as the absence of errors due to movements of the instrument as a whole and the permanence of the calibration, there is the great advantage that once it has been attached to the test-piece, no further handling of the instrument is necessary during the course of an experiment. Thus, temperature effects arising from this cause are entirely obviated.

This latter feature encouraged Professor Lamb to attempt to apply the principle to the measurement of the very small lateral expansions and contractions of a test piece under longitudinal strain. The result of this work has been the evolution of the instrument shown in Fig. 2, and diagrammatically in Fig. 3. In Fig. 2 the appliance is seen in position on a cylindrical compression test-piece of about 1¼-in. diameter. It will be noticed that the arrangement comprises a light steel frame consisting of two rigid cross members A and B, Fig. 3, held together on either side of the test-piece by two parallel bars, the member A carrying a stop, having a screw adjustment which bears against one side of the test-piece while mounted in B is a moving block held against the opposite side by spring pressure. This moving block is guided by the small measuring rollers C and D disposed diagonally on either side of it and by two steel balls running in V grooves, also disposed diagonally on either side. Lateral pressure on the rollers and balls is maintained by a spring. The measuring rollers are of silver steel carefully finished by lapping to about 0·025-in. diameter, and each carries a plane mirror at its upper extremity, being provided also with a small knurled head at the lower end. The cross member B is permanently fixed to the side bars, while A can be clamped in any position on them to accommodate test-pieces of various sizes, and, by screwing forward the stop in A, the instrument grips the test-piece, at the same time depressing the moving block in B against the spring to approximately the centre of its total movement. Since the test-piece is held at two opposite points only a small and moderately flexible steadying bracket is fixed to the screw stop in A. This may be observed on the left of the test-piece in Fig. 2. The flexible bracket is provided with two small screws which can be adjusted to bear lightly against the test-piece and thus prevent the instrument from toppling over.

The subsequent operations of erecting the telescope and scale are similar to those required for the longitudinal extensometer, the mirrors being rotated if necessary by means of the small knurled heads on the ends of the rollers.

On account of the high sensitivity of the arrangement and the necessary handling of it in attaching it to the test-piece, the taking of observations must usually be deferred for a period of at least 30 minutes, until the instrument has assumed the temperature of the room. It may be remarked that the effect upon the scale reading of placing the hand at a distance of about ½ in. from one of the side bars for a period of 10 to 15 seconds only is easily discernible, and, consequently, it is necessary to ensure that the apparatus, when in use, is shielded from draughts and the direct rays of the sun. As in the case of the direct extensometer, no injury is suffered if still in position on the test-piece when fracture occurs.

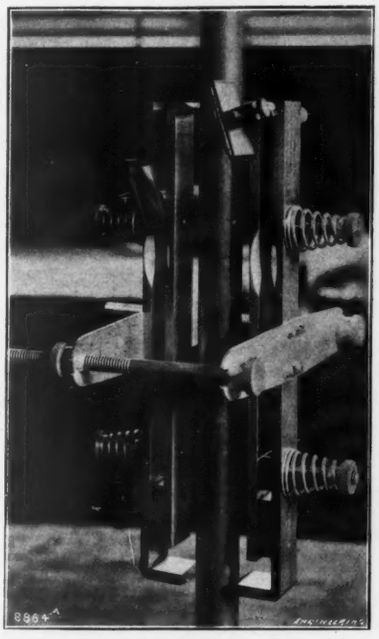


FIG. 1.

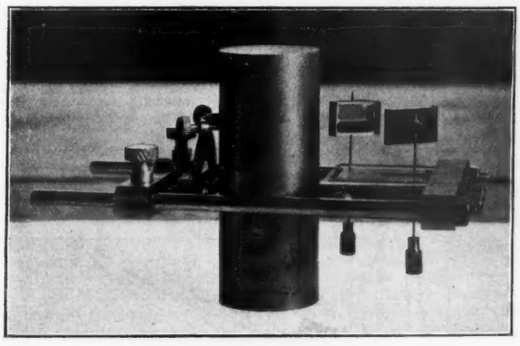
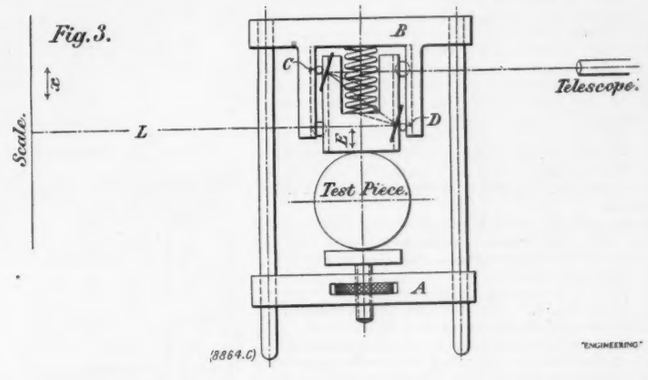


FIG. 2.



The geometry of the optical arrangement is the same as for the longitudinal extensometer, the relation between the scale reading x (in centimetres) and the movement E (in inches) of the moving block is (see diagram, Fig. 3)—

$$E = \frac{d}{4L + 2a}\, x$$

where d = mean of the diameters of the rollers C and D in inch units,
L = distance from the scale to the mirror facing it in centimetres,
a = distance between the two mirrors in centimetres.

The accuracy obtainable is naturally of the first importance to an experimenter, and in this connection it is to be remarked that the roller diameters (approximately 0·025 in.) can be measured easily to 0·00001 in., or within 0·05 per cent. This measurement is the primary calibration of the instrument and can be repeated at any time with ease, it being necessary, of course, to remove the rollers for the purpose. Of the remaining quantities in the above expression for E, the scale distance L, which will usually be from 200 cm. to 400 cm., can be conveniently found with a tape to an accuracy of 0·25 per cent. to 0·10 per cent.; a is approximately 2 cm.; and with a scale distance of about 300 cm. it is easy to read the scale x to 0·2 mm. Under these conditions a round steel test bar of only ¾ in. diameter, stressed to near the elastic limit would give a scale deflection of rather more than 10 cm., so that the lateral contraction can be obtained to well within 0·5 per cent. without difficulty.

In order to check the behaviour of the complete mechanism—that is, to examine the agreement between the values obtained for E, as calculated by the formula above, with the actual movements of the block in B, it was mounted in a measuring machine so that known movements could be given to the block, and the observations with a telescope and scale were taken in the usual way. This method of calibration is not so simple as might at first sight appear, much care being necessary over such details as the method of supporting the instrument to avoid errors arising from slight "canting," which would impart small displacements of unknown amount to the block. Successive displacement increments of 0·0002 in. were given by means of the micrometer head of the machine, the circle of which is divided into intervals of 0·0001 in., these being again subdivided into tenths by a vernier. The possible limits of error in setting the micrometer are about ± 0·000004 in., or ± 2 per cent. of the increment given. The scale was set up at a distance of 178 cm. from the mirror which faces it, the rollers of the instrument used having a mean diameter of 0·02556 in. Table I gives the increments observed on the scale for seven successive displacements in each direction, returning to the same initial reading of the micrometer.

TABLE I.

Inward displacements		Outward displacements.	
Scale increment.	Difference from mean value.	Scale increment.	Difference from mean value.
Cms.		Cms.	
5·63	+0·01	5·62	0
5·58	−0·04	5·65	+0·03
5·62	0	5·70	+0·08
5·58	−0·04	5·62	0
5·60	−0·02	5·56	−0·06
5·66	+0·04	5·59	−0·03
5·68	+0·06	5·60	−0·02
39·35		39·34	

It is to be noticed that the greatest deviation from the mean value amounts to only 1·4 per cent., which is well within the limits of error due to setting the micrometer. Using the formula given above, the calculated scale increment for a block displacement of 0·0002 in. is 5·604 cm., which, compared with the observed mean value of 5·620, shows an error of only 0·3 per cent. There is little doubt that with greater precautions to ensure more uniform temperature conditions and avoid draughts these results could be improved upon.

Table II is a record of the actual behaviour of this instrument when measuring the lateral contractions of a round steel bar in tension in the testing machine. The greatest deviation from the mean difference in

this table is about 5 per cent. of the mean value, which must be regarded as very satisfactory seeing that the final digit in the second column represents the estimated subdivision of a millimetre on the scale,

TABLE II.

Diameter of steel bar = 0·749 in.; Scale distance (L) = 456 cm., a = 2 cm.; Mean of roller diameters (d) = 0·02556 in.

Tension.	Scale.	Scale increment.	Difference from mean.
Tons.	Cm.	Cm.	
0	11·47		
0·5	12·80	1·33	+0·02
1·0	14·07	1·27	−0·04
1·5	15·37	1·30	−0·01
2·0	16·69	1·32	+0·01
2·5	17·98	1·29	−0·02
3·0	19·31	1·33	+0·02
3·5	20·60	1·29	−0·02
4·0	21·91	1·31	0
4·5	23·28	1·37	+0·06
5·0	24·57	1·29	−0·02
4·5	23·24	1·33	+0·02
4·0	22·00	1·24	−0·07
3·5	20·69	1·31	0
3·0	19·40	1·29	−0·02
2·5	18·08	1·32	+0·01
2·0	16·76	1·32	+0·01
1·5	15·42	1·34	+0·03
1·0	14·10	1·32	+0·01
0·5	12·75	1·35	+0·04
0	11·45*	1·30	−0·01

(Mean value of scale increment = 1·310)

* At the end of the experiment the zero reading was found to be unsteady owing to temperature effects, varying between 11·40 and 11·50; it is probable therefore that most of the observed deviations from the mean value of the increment are due to this cause.

and also in view of the fact that the experiment was carried out on a very windy day, when the laboratory was by no means free from draughts.

The instruments described above were made to Professor Lamb's drawings by Mr. A. Macklow-Smith, of 15 and 16, Queen Anne's Chambers, Westminster.

ANTI-FRICTION BEARING APPLICATIONS FOR HEAVY DUTY.*

By J. B. DAHLERUS.

PRACTICAL experience has indicated that ball bearings could certainly deal with heavy loads at comparatively high speeds, but such bearings would have to be of dimensions which were quite impracticable in many cases, so that the practical side of the problem resolved itself into producing a bearing which would be able to deal with approximately twice the amount of load that a ball bearing of the same dimensions would take. Such a bearing should also have the following characteristics, the value of which will be evident:—(*a*) Minimum friction. (*b*) Capable of dealing with both radial and thrust loads. (*c*) Ability to deal with thrust load in either direction. (*d*) The unit should be self-contained, have no loose parts, and should be non-adjustable. (*e*) Should be capable of quick inspection. (*f*) Should have the feature of self-alignment.

These demands are of a very stringent nature, and it was only after most exhaustive research that a bearing capable of meeting each and all of these conditions was produced.

A section of the bearing illustrating the main features is shown in Fig. 1. These features are as follows:—(1) The raceway in the outer ring is spherical. (2) The rollers are barrel-shaped, and the greatest diameter is not at the centre of the roller, but is offset towards the centre of the bearing. (3) The inner ring has two grooves for the rollers, as indicated, these grooves having exactly the same radius of curvature as that of the roller. (4) The end of the roller towards the centre of the bearing is ground spherically, as is also the flange on the inner ring against which the roller end bears. Since the surfaces in contact are spherical there is a definite area of contact, which extends on each side of the plane A B, indicated by the light hatched lines. This is an extremely important feature. (5) The fact that the large diameter of the rollers is offset towards the centre of the bearing means that a certain small proportion of the radial load on the bearing keeps the roller in continuous contact with its mating flange. Consequently, should there be the slightest tendency for the roller axis to get out of parallelism with the axis of the bearing, this tendency is immediately corrected by the width of the contacting areas. This arrangement has the effect of:—(*a*) Keeping internal friction of the bearing to a minimum on account of reduction of slippage between contacting surfaces. (*b*) Relieving the cage of any stresses which would be set up by the skewing tendency of the rollers were this not so counteracted. (6) The curvature of the rollers is slightly greater (that is, the radius is smaller) than the spherical race-track in the outer ring. The difference, however, is very slight, but sufficiently so to ensure correct functioning. (7) The lines through the neutral points in the roller contour which converge to the apex a on the axis of the bearing are virtual tangents to the roller surfaces, and consequently conform practically, if not absolutely, to the theory of pure rolling motion.

The double row roller bearing thus described has actually twice the capacity of a ball bearing of similar dimensions, and provides the necessary flexibility, which will compensate for slight errors in manufacture of housings, as might naturally be expected in heavy work. The bearing, however, does not provide for lateral flexibility, and to obtain this the well-known type of cylindrical roller bearing has been adopted. The usual parallel outer race, however, is such that it does not permit of any self-alignment and only adapts itself to lateral displacement. The consequence of this was the modification as shown on Fig. 2. The chief feature here is that the raceway in the outer ring is not cylindrical, but convex. The convexity is not great, and is just sufficient to permit of a very slight amount of misalignment taking place, without interfering with the correct functioning of the bearing. It also has the added advantage that there is less tendency for the rollers to "skew" in the tracks, since the controlling forces must operate within the width of the roller, and cannot operate at the roller ends (unless in the case of severe misalignment).

It has been stated above that one of the essential features of a roller bearing is minimum friction, and as a matter of interest, Table I of the relative coefficients for various types of anti-friction bearings is given, together with the authorities for the data. Items 2 to 6 have also been confirmed by the American Society of Mechanical Engineers and other workers.

Fig. 1. SPHERICAL ROLLER-BEARING

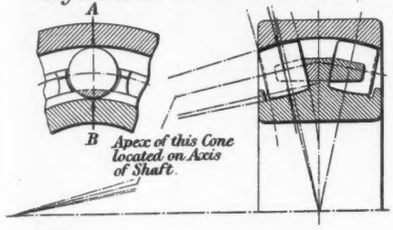


Fig. 2. CYLINDRICAL ROLLER-BEARING.

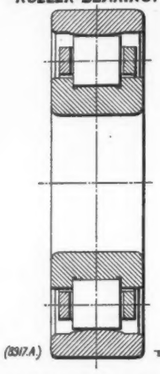
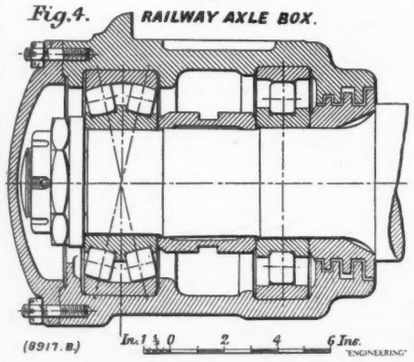


Fig. 4. RAILWAY AXLE BOX.



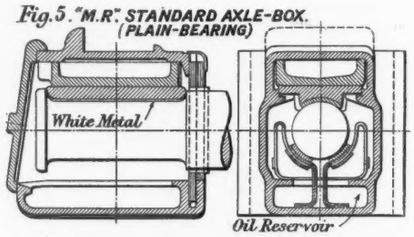
The coefficients in Table I obtained under test assume correct lubrication, and while it is well known that lubrication for anti-friction bearings is not required in the same sense as for plain bearings, it is not so well known that the type of lubricant or the quantity used may have a considerable effect on the coefficient of friction and operation of the bearing.

TABLE I.—*Average Coefficients of Friction for Ball and Roller Bearings.*

1 Single-Row Rigid Ball Bearing.	2 Double-Row Self-aligning Ball Bearing.	3 Long Cylindrical Roller Bearing.	4 Flexible Roller Bearing.	5 Short Cylindrical Roller Bearing.	6 Taper Roller Bearing.	7 Double-Row Self-aligning Roller Bearing.
0·0015	0·0010	0·003 to 0·01	0·004 to 0·007	0·0010 to 0·0015	0·002 to 0·004	0·002 to 0·0035

The authorities for the above figures are as follows:—
1. National Physical Laboratory.
2 to 6. Professor Goodman (Proc. Inst. Civil Engineers, vol. clxxxix).
7. Will be referred to later on.

Fig. 5. "M.R." STANDARD AXLE-BOX. (PLAIN-BEARING)



"M.R." AXLE-BOX (ROLLER-BEARING)

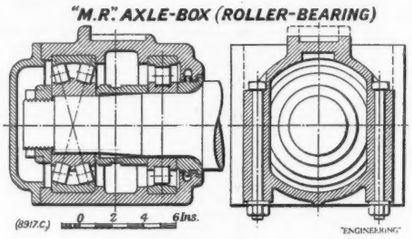
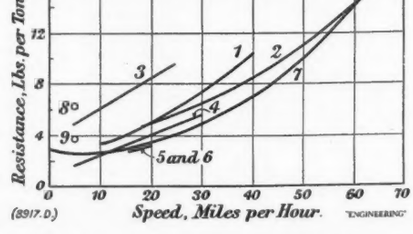


FIG. 6. TRAIN RESISTANCE CURVES. PASSENGER STOCK.

1. Aspinall's curve for five coaches.
2. Barbier's curve.
3. Coasting test down gradient 1 in 94. Plain bearing.
4. L.M.S.R. Midland, Passenger Coach: down gradient 1 in 94. Roller bearing.
5. L.M.S.R. Midland, Passenger Coach: on level. Plain bearing.
6. L.M.S.R. Midland, Passenger Coach: on level. Roller bearing.
7. Suggested roller-bearing curve.
8. Pennsylvania Railroad coach (60 tons), plain bearings.
9. " " " " ball bearings.



Railway Work.—In the endeavours to obtain satisfactory anti-friction bearing applications to heavy work, railway rolling stock proved very attractive, and several attempts were made to apply both ball and roller bearings several years ago. In the light of present-day research, however, it may be concluded that the capacity of the bearings used did not have a sufficient factor over the static loads to give sufficiently long life. As a matter of fact, in some cases it is clear that only about twelve to eighteen months' running could have been logically expected.

In view of the unsatisfactory life indicated by most of these early experiments, it was clear that a radical alteration in design was necessary. Research regarding endurance indicated that the factor over the dead loads should range between 2·5 and 3·5. Experiments were carried out on the Swedish State Railways with a specially designed shock absorber, so that data might

* Paper read before the Institution of Mechanical Engineers on Friday, February 6, 1925. Abridged.

be collected as to the radial and lateral shocks in railway axle-box service.

The principle of the instrument used is based on the inertia of a metal cylinder supported on a light spring and suitably connected to the recording apparatus, where the shock is registered in the usual manner as an ordinate in a continuous curve. The information obtained in this way provided the following generalisations regarding lateral and vertical loads.

The average accelerations of the axle-box in the vertical direction at 60 m.p.h. were :—

At joints = 190 m. per sec.^{2} (623 ft. per sec.^{2})
In switches = 260 m. per sec.^{2} (853 ft. per sec.^{2})

The acceleration in the lateral direction for the axle-box, as well as the frame, was, on an average, 13·5 m. per second^2 (44 ft. per second^2), measured at the box, which was placed at a distance of 1·2 m. (4 ft.) from the centre line of the bogie. These various accelerations were approximately proportional to the speed.

In the case of a 5-ton static radial load—the weight of the axle-box and support being 2 cwt.—the radial shocks were as follows :—

At joints = 4,180 lb. = 31 per cent. addition.
In switches = 5,720 lb. = 52 per cent. addition.

Assuming the weight of the bogie-frame to be 6,600 lb. and the inertia radius 1 m. (3 ft. 3 in.), the lateral shocks would be 6,116 lb. = 55 per cent. addition to the journal load.

Of course, these additional loads are only momentary, the radial shocks being more frequent than the lateral forces, and it was, accordingly, considered that the following additions to the deadweight would cover service conditions.

For passenger bogie-cars with a maximum speed of 60 m.p.h., and design as shown on Fig. 4, an addition of 20 per cent. radially and 15 per cent. laterally on the spherical-type bearing should meet the case. The additional radial allowance on the cylindrical bearing would be 25 per cent. of the deadweight.

For goods work with a maximum speed of 40 m.p.h., and a design similar to that in Fig. 4, an increase of 10 per cent. radially and 5 per cent. laterally on the spherical bearing should be ample, the increase on the radial load for the cylindrical type being 12 per cent. It is usually found that the two roller bearings—that is, one spherical and one cylindrical type—in conjunction provide a factor of 3 to 3·5 over the deadweight on the journal, and the endurance is consequently anticipated to be all that is required.

Midland Railway Tests.—The results obtained by the Midland Railway Company in testing out their standard plain-bearing journals against roller-bearing axle-boxes, as shown in Fig. 5, form a useful basis for discussion.

Various resistance curves have been collected in Fig. 6, and additions made from recent test results. Considering Fig. 6, curve (5) represents the resistance values obtained by the Midland Railway Company with their standard stock during a coasting test. These values are resistances taken on straight, level track.

Curve (3) is the corresponding resistance curve for the same stock during the first three minutes of the coasting test when the train descended a gradient of 1 in 94. In contrast with these are curves (6) and (4) giving corresponding data for the roller-bearing equipment. A study of these curves reveals the unusually low values obtained for the running resistance with the Midland passenger stock. The result must be taken in conjunction with Table II, where resistance values are given at various points throughout the test run between Kentish Town and Leicester.

It will be noted that the results are not strictly in agreement, as while the resistance in the plain bearing-boxes appeared to drop to its minimum value after 3 or 4 minutes' running during the coasting test, it required 56 miles travel on the Leicester trip to achieve the same condition. It should be explained that the resistances given in Table II do not refer to straight, level track, but were abstracted at points irrespective of track profile to give comparative values.

Taking a broad view of both tests, they indicate the possibility of the plain journal having achieved an efficiency equal to that in the roller-bearing box after the state of permanency is reached, thereby necessitating a review of previous views on plain journal friction. In this connection it has been customary to quote the work of Tower and Stroudley. Considering these, it is found that Tower obtained a coefficient of 0·006 with pad lubrication, and in another experiment with a 4-in. diameter journal, 6 in. long, lubricated by pad with rape oil, he deduced values for speeds ranging between 150 r.p.m. and 300 r.p.m. and pressures of 310 lb. and 293 lb. per square inch. The average coefficient in these experiments is just under 0·01. Stroudley obtained a figure of 0·0077 for intensity pressures between 277 lb. and 333 lb. per square inch, lubrication here also being by pad.

Mr. Carus-Wilson (Proc. Inst. C.E., Vol. clxxi, Part 1) accepted the value of 0·0077 in his estimation of friction loss. To prove this standpoint, an opportunity was given to review the test results of the Midland Railway Company with respect to their plain journals. The machine on which the tests were conducted is used chiefly to check lubricants. The journal is 3½ in. diameter by 8 in. long, and a load of 2 tons is applied to the gun-metal journal, where an effective surface of 2¼ in. by 6¾ in. gives an intensity pressure closely in accordance with that operating in the standard boxes, where the journal dimensions are 3¾ in. diameter by 9 in. long. The rotational speed corresponds to 50 m.p.h., and the axle is given a slight lateral movement during rotation. The bearing is run for 2 hours. The frictional resistance is registered in the usual way by a spring balance at the end of a lever, equivalent to the wheel radius. The reading is taken at the end of 5 minutes' running, and finally at the end of the test. An examination of numerous tests conducted with high quality Globe oil, specific gravity 0·906, with a commencing temperature of 60 deg. F., and rising to about 120 deg. F., showed the coefficient of friction at the end of 5 minutes to be 0·012. The corresponding figure at the end of 2 hours' running was 0·0074, giving an average throughout the run of 0·0094. These figures give close agreement with the generally accepted values, and doubtless apply to the Midland Railway stock in newly assembled boxes.

TABLE II.—*Train Resistances.*

Miles from Start.	Speeds in Miles per Hour.		Resistances in Pounds per Ton.	
	Roller.	Plain.	Roller.	Plain.
	Kentish Town–Leicester.			
1½	23·4	23·7	7·56	9·70
10	33·3	32·7	7·07	8·76
11¾	60·5	60·0	12·33	14·11
13½	46·2	45·0	10·69	12·47
17½	51·5	53·8	9·14	10·00
24	54·6	58·6	11·39	13·38
33	60·5	61·5	11·23	12·01
34	64·8	65·5	11·50	12·10
35	67·9	69·2	11·49	13·04
43	68·0	67·9	11·26	11·82
56	41·8	43·9	6·96	8·13
60½	63·2	64·4	9·74	9·67
68½	53·6	55·8	7·75	7·54
72	41·8	42·8	7·32	7·04
76	37·4	37·5	9·23	8·44
77½	47·4	45·6	11·96	12·11
80	64·3	58·1	8·53	8·02
86½	49·3	46·1	9·22	7·54
88½	43·9	42·9	10·52	9·90
91	62·1	60·0	11·45	12·10
	Leicester–Kentish Town.			
6½	39·5	38·0	9·28	9·35
9	37·9	37·0	9·21	9·98
11	54·6	54·0	14·37	13·27
17½	32·4	34·0	8·15	7·37
20	27·5	25·0	8·68	7·85
21½	47·4	47·0	13·29	12·94
25½	60·0	60·0	8·71	9·89
29	60·0	59·0	7·28	6·60
40	31·0	34·0	6·04	6·65
43	59·1	64·0	9·30	8·85
54	32·7	35·5	12·46	10·32
57	32·1	33·5	10·07	8·15
70½	54·2	50·5	10·65	9·72
75½	58·2	55·0	10·86	9·62
80	66·5	62·5	14·86	11·22

It is evident that there is a decided discrepancy between orthodox tests of this kind, and the actual state of affairs in service. An examination of the white-metal bearings taken from Midland Railway coaching stock after 100,000 to 150,000 miles' running, showed that these had a mirror-like surface. The bearing is relieved at the sides during erection, so that the actual bearing area is not definitely determinable, but through time the journal beds itself in at the most comfortable position. It should be explained that the workmanship and maintenance of these plain-bearings on the Midland stock is of the highest quality, the journals being truly round with perfect finish, and only the finest material used in the brasses and lubricant. The results are consequently more or less in accordance with orthodox practice, so far as the running-in period is concerned, the difference referring essentially to the high efficiency ultimately achieved in service.

The friction loss in the test machine during the first 5 minutes' running, in conjunction with the high resistance values in the coasting test, and the first eleven values for the resistance in Table 2, show the time necessary for the most efficient white metalled axle-boxes to recover from the stiction condition. It is estimated by the Midland Railway Company that probably at least 1 month's running is necessary to bed in the journal on the white metal. During this period the friction co-efficient is probably in the region of 0·007 to 0·01. In cold weather, or on short distance work, these values would still be maintained, but on long distance express traffic, where the bearing has an opportunity to achieve a state of permanency, the co-efficient may commence at 0·01 but drop ultimately to 0·002.

In Fig. 6, curve (7) represents the anticipated roller-bearing resistance for standard British bogie passenger coaches. It will be noted that the Midland Railway results are closely in accordance with prediction. This curve is expressed by the following formula :—

$$R = \frac{2{\cdot}6 + (V - 8)^{1{\cdot}7}}{76{\cdot}8}$$

where R = Resistance in lb. per ton ;
V = Speed in miles per hour.

This experience in conjunction with other records shows the difficulty of generalising from particular data. The reduction in the running resistance in passenger stock clearly varies considerably with the nature of the traffic, as well as the design and maintenance conditions.

The following additional data regarding these tests is given :—For the plain-bearing axle-boxes a blended oil, composed of 80 per cent. of the Vacuum Oil Company's Globe mineral oil and 20 per cent. of olive oil, was used, but for the roller-bearing axle-boxes, the Vacuum Oil Company's Globe mineral oil only was used.

Particulars of Trains Tested.—Set train No. 232, consisted of thirteen four-wheel bogie passenger stock vehicles, having a total weight empty of 312 tons, and total length over buffers of 649 ft. This train was fitted with roller-bearings for the axle-box journals, on the coaches only.

Set train No. 233 was identical with the above, with the exception that Midland standard plain bearings were fitted on the axle-box journals.

Tests.—On Sunday, April 15, 1923, the two trains were worked from Kentish Town to Leicester and back under similar conditions, the coal consumption being taken and the work done on the trains being recorded by the dynamometer car, which was coupled up between the engine and train being tested. The complete trip between Kentish Town and Leicester and return is 195 miles. The same class of coal was used throughout the tests.

TABLE III.—*Comparison of Coal Consumption—Sunday, April 15, 1923.*

Kentish Town to Leicester and Return.

———	Plain-Bearing Train.	Roller-Bearing Train.
Train, car and engine .. tons	444·6	444·6
Mileage (Kentish Town to Leicester and return)	195·0	195·0
Coal used .. .. .. lb.	5,898	6,387
Coal per ton-mile .. .. lb.	0·06803	0·07367
Coal per mile .. .. .. lb.	30·2	32·8

The above figures show that with the roller-bearing train, the coal consumption was increased 8·28 per cent. compared with the plain-bearing train.

Compound engine No. 1034 worked both trains, the timings were as near as possible identical, and the weather conditions remained practically constant throughout the day, except for the last part of the return trip with plain bearings, when it rained slightly for about one hour. It was necessary, however, for different sets of men to work the two trains. The results obtained are shown in Tables III and IV.

TABLE IV.—*Comparison of Resistances of Plain and Roller-Bearing Trains.*

Kentish Town to Leicester and Return.

———	Plain-Bearing Train.	Roller-Bearing Train.
1. Weight of train, excluding engine and dynamometer car .. .. .. tons	312	312
2. Total distance run, as recorded by dynamometer car miles	195·10	195·23
3. Net work done in working the train, as measured by the integrator .. .. ft.-lb.	3,285,174,750	4,484,280,250
4. Total running time .. hours	4·417	4·449
5. Average speed .. .. m.p.h.	44·17	43·88
6. Average draw-bar pull at rear end of dynamometer car tons	1·424	1·510
7. Average resistance in lb. per ton (train only)	10·223	10·841
8. Increase in case of roller bearings, as compared with plain bearings	—	6·04

From the figures quoted it will be noted that, although the average speed of the roller-bearing train was slightly less than that of the plain-bearing train, the coal consumption was 8·28 per cent. more and the net work done, as recorded by the dynamometer car, 6·04 per cent. greater.

Train resistances have been deduced from the dynamometer records whenever it was possible to ensure that the whole of the train was on the same gradient, and these resistances are given in Table II. From this it will be seen that, while at the beginning of the outward run the roller-bearing train indicated a

lower resistance than the plain-bearing train, after some distance had been covered, conditions were reversed, the plain-bearing train showing the lower resistance. Thus, although starting at a disadvantage as compared with the roller-bearing, the plain-bearing gradually improved until it became more efficient than the roller-bearing, and therefore on a run of any length the total work done, as measured by the integrator, is less for the plain-bearing train.

On Sunday, April 22, 1923, coasting tests were made between Westcliff and Benfleet, with each of the above trains under similar conditions, the first portion of the run being on a down grade of 1 in 94, full particulars being recorded by the dynamometer car.

From the preceding trials it was not possible to obtain detailed information with regard to the comparative resistances at slow speeds, and it was decided to carry out coasting tests, the dynamometer car being fitted to the rear of each train in order to obtain an accurate record of the speed. The reaction between the train and the car was also recorded, so that it was

FIG. 7. COASTING TESTS. PLAIN AND ROLLER BEARINGS.

Westcliff-Benfleet. Sunday, April 22, 1923.

Set train { No. 232. Roller-bearings, dotted lines. / No. 233. Plain bearings, full lines.

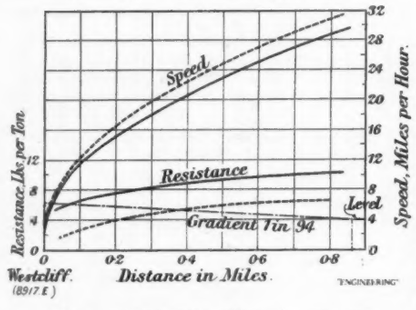


FIG. 8. COASTING TESTS. PLAIN AND ROLLER BEARINGS

Westcliff-Benfleet. Sunday, April 22, 1923.

Resistances immediately after starting.

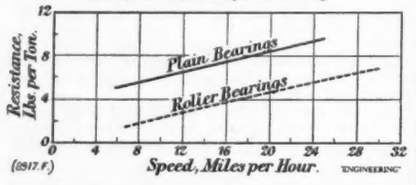
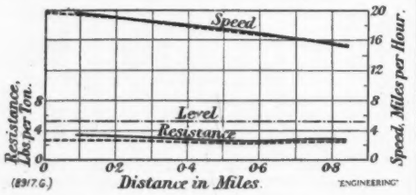


FIG. 9. COASTING TESTS. PLAIN AND ROLLER BEARINGS.

Westcliff-Benfleet. Sunday, April 22, 1923.

Set train { No. 232. Roller-bearing, dotted lines. / No. 233. Plain bearing, full lines.

Note.—The two trains were not on the same portion of the line.



possible to obtain values for the resistance of each train by eliminating the effect of the dynamometer car. The results of these tests are shown graphically in Figs. 7, 8, and 9.

Fig. 7 gives the speed for the two trains at the same points on the bank, plotted on a distance basis. Resistances are also shown for the two trains, these values being calculated from the acceleration derived from the time pen on the dynamometer record. The rotary inertia of the wheels of the train has also been included in the calculations, being an average of 8 per cent. of the net weight of the train. The results have been plotted on a speed basis, as shown in Fig. 8.

In Fig. 9 the speeds of the two trains are plotted when running on the level and the track straight, portions of each trip being chosen for comparison at which the speeds of the train were approximately the same. Train resistances for these speeds were calculated and plotted by the same method as for Fig. 7.

In comparing Figs. 7 and 9 it will be noted that in Fig. 7, which shows the first portion of the coasting test down the bank, the acceleration with the roller-bearing train is appreciably greater compared with that for the plain-bearing train, and the maximum speed recorded with the roller-bearing train was 32 m.p.h. at the bottom of the bank. With the plain-bearing train the maximum speed was about 29 m.p.h. at about the same point.

Again, the resistances for the roller-bearing train, as shown in Fig. 7, are considerably less than those for the plain-bearing train at similar speeds.

On Fig. 9, in which the trains were running on the level at similar speeds towards the end of the run, it will be noted that the difference in the resistances for the two trains is practically negligible. The roller-bearing train is still in service to determine endurance, and periodical examinations are made to ascertain the condition of the boxes. So far the examination has revealed that the bearings are standing up to their work without the slightest sign of stress.

The sizes of the bearings in the Midland Railway boxes are as follows: Spherical roller-bearing, 90 mm. bore by 190 outside diameter by 64 wide. Cylindrical roller-bearing, 95 mm. bore by 200 outside diameter by 45 wide.

(To be continued.)

NOTES ON NEW BOOKS.

MR. MUNRO SMITH has produced a very interesting work of 300 pages in his book on the "*Design and Construction of Small Craft*," published by the Technical Section, Association of Engineering and Shipbuilding Draughtsmen, London (price 12*s.* 6*d.* net). This should be useful for reference purposes to all having to do with tugs, fishing vessels, self-propelled barges, launches, pilot-, ferry- and fire-boats, coasters, dredgers, passenger and light draught vessels. Separate chapters are devoted to the types described and each contains a considerable amount of information, some of which has already been published in the leading periodicals. These indicate the functions of the craft and will provide guidance to those concerned with the design of such vessels. It is evident that the author is a strong advocate of the internal-combustion engine, for in practically all the vessels he has dealt with reference is made to the advantages which he claims for such engines. Numerous diagrams are given showing the relation between dimensions, speed, deadweight, &c., and these may be useful as a "jumping off" position in the early stages of a design, although they would require careful verification before a designer could commit himself to contract conditions for such tricky classes of vessels; as an instance, one might cite the diagrams given for paddle and screw passenger vessels, and it will be seen that these can only be of very general service. When discussing the design of river and canal barges, the author implies that in 1850 these vessels were not built to any proper design, and that boat-builders relied solely upon their knowledge and experience of the waters in their vicinity. It is thought that such a condition of affairs was not then confined to that type of craft; rule-of-thumb methods were applied to all classes of vessels, even for our Government vessels, the designs of which were largely under the control of carpenters. Numerous formulæ and tables for propellers and equipment are given, which will be found useful for comparative purposes, although some of them might have been stated in simpler fashion. The author rightly lays stress upon the necessity of reducing the weight of steel and equipment of shallow-draught vessels, but it may be suggested that he would have added to the value of the work if he had added a paragraph or table to show the value of draught for such vessels, as it is not always realised by those who prescribe the design conditions, that an extra inch of draught may yield more than can possibly be saved by reduced weights.

A theory of the pressure which earth, in the form of natural or made ground, exerts against a retaining wall was laid down by Coulomb 150 years ago, and the subject was taken up subsequently by Rankine, Müller-Breslau and, within the last few years, the subject has been worked at by Krey and by Freund. It seems quite possible, however, that the most important of the recent contributions to this difficult subject will prove to be that due to Mr. S. D. Carothers, of which an account was given in an article which appeared on page 1 of our issue of July 4 last. On the usual theory the wall is regarded as opposing a certain horizontal reaction to the thrust of the earth. This reaction must exceed a certain minimum or a slip will occur, whilst if it exceeded a certain maximum the earth would be forced up. The minimum reaction may be zero when the cohesion of the ground or rock is sufficient to maintain a vertical face of the ground without any supporting wall, and since the earth particles settle in the course of time more than the bricks of the wall, so will the cohesion ncrease, but in a measure to which numerical values can hardly be attached; retaining walls may hence prove to be stronger or weaker than they should apparently be. Professor Richard Petersen, of Danzig, deals with the working out of such problems by formulæ and graphs in his monograph on "*Erddruck und Stützmauern*" (Berlin: Julius Springer; price 5·40 gold marks).

The new edition of the late Judge Shiress Will's book on the law of electric lighting ("*The Law Relating to Electric Lighting, Power and Traction*," by the late Judge Shiress Will, K.C. 5th edition by John C. Dalton; London: Butterworth & Co. 42*s.* net) is published opportunely at the present time, when the use of electricity for lighting, power and traction has developed enormously, and is still extending, and the practitioner has to track his way through a series of Acts passed at different times during the last thirty years. The legal profession should be grateful to the new Editor, Mr. John C. Dalton, A.M.I.E.E., of Gray's Inn, Barrister-at-Law, for the care and industry with which he has gathered together and annotated in one volume all the statutory enactments bearing on the subject. The task is in its nature perhaps a somewhat thankless one, because the subject is highly special, and for a hundred people who might read, say, Pollock or Anson on Contract, or Dicey's Law of the Constitution, from cover to cover, very few would read for pleasure this volume of over 400 pages of annotated statutes and regulations. Nevertheless, it will be a great relief to the legal advisers of local authorities and electric supply companies that an electrician and lawyer has been sufficiently devoted to set out for them the whole law on the subject as clearly and plainly as it can be done. The new edition is a good book, carefully, clearly and well written, and even, as a rule, properly punctuated, which last can be said of few recent law books. In an introduction of about fifty pages, the Editor—we should almost say "the new author," for the book is practically a new one—gives a useful summary of the legislation on the subject, showing the development under the Electric Lighting Act, 1882, and the Electricity Supply Act, 1892, and dealing specially with the great changes made by the Acts of 1919 and 1922, which provided for the appointment of the Electricity Commissioners and the setting up of joint electricity authorities. It also touches on the situation in the London area, and the impending legislation for that district. The introduction is followed by all the statutes printed in full with a careful and often elaborate commentary on each section. The amount of commentary and annotation indicates of itself the complexity of the subject, for it would be almost true to say that each statute alters its predecessors. We see the change of procedure from license to provisional order, and now special order; the transfer of powers from the Board of Trade to the Minister of Transport, and their delegation by him to the Electricity Commissioners; the amendment in favour of the undertakers of the local authorities' power to purchase their undertakings; and innumerable other changes and developments. But the conclusion is inevitable that the sooner the existing statutes are repealed and consolidated, the better for everyone. The only thing about the book which cannot be commended is the yellowish tint of the paper on which it is printed.

It is related of Steiner, one of the great Swiss mathematicians, that he considered it a disgrace that any geometrical theorem should be discovered by analysis instead of geometrical intention. Judging from three essays we have just received from Messrs. E. J. Bull, Limited, of Leiden, it would seem that their author, Professor C. P. Holst, who held until recently the chair of Mechanical engineering at Delft, has considerable sympathy with Steiner, although he certainly does use analytical methods as an aid to his geometry. One of the essays is entitled "*The Rectification of Circular Arcs.*" It describes a variety of geometrical methods of finding straight lines equal to given arcs, or arcs equal to given straight lines. Some of the simple and ingenious constructions given are remarkably accurate. The second essay is a detailed study of "*The Geometry of the Screw Propeller*," whilst in the third Professor Holst gives a profound study of "*The Connecting Rod and Crank Mechanism and its Inertia Forces.*" This subject is dealt with both analytically and graphically. All three essays are in English, of which the author has a thorough command.

Almost everybody has something to do with gas meters. To most people, however, the gas meter is not only a closed instrument beyond their control, but may also be said to be a sealed book. The meter is supposed to record the amount of gas used; how, the ordinary citizen does not understand, but as he has to pay for the amount recorded, and though perfection is not claimed for the meter, he has to be content to let it remain a

sealed book. Mr. Albert T. Gilbert, late of the South Metropolitan Gas Company, in his "*Gas Meters: Their Construction, Use, Fixing, Inspection and Maintenance*" [London: Crosby Lockwood and Son; price 7*s.* 6*d* net], offers a handbook, which, though written in semi-popular language, is intended for engineers and managers, inspectors, fitters and students, and not for the general public. The main chapters deal with wet and dry meters, their construction, repair shop practice, testing and hints to managers, fitters, &c. Inferential meters have a rather short chapter of their own, which contains the only literature reference we have noticed in the volume. We find mention of the Life of Gas Meters Committee in the introduction and in one or two places of the book; but the actual reports of this committee of 1916 and 1917 and later years are not quoted, though inspectors and fitters might be glad to know where to look for further information. Gas calorimeters are not noticed, and the index is poor. As one of the volumes of Lockwood's Trade Manuals, the book is commendable.

It has been said by a Commissioner of the United States Patent Office that industry is based on patents, and any new work on the subject of inventions and patents generally is worthy of consideration, but the chief test of the value of the work is whether or not it contributes something new to the literature on the subject. "*Patents: Invention and Method*," by Harold E. Potts (The Open Court Company, London, Price 3*s.* 6*d.*), unfortunately, except for a short introduction and brief appendix, consists of a reprint of articles which have appeared in *Nature*, *The Journal of the Society of Chemical Industry*, *The Chemical Age*, and papers read before the Chartered Institute of Patent Agents. The publication, which is very clearly printed, may be of use for purposes of propaganda and some may care to have these articles grouped in one book for reference purposes. The author states: "I am reprinting these papers because they have interested me even though any interest they may have for others is more academic than practical." This appears to be a fair summary of the work. As regards technicalities, an example of a suitable claim for a patent dealing with the use of cerium and thorium salts is given, and it is suggested that these may be covered by reference to refractory oxides or chemicals giving, with a certain foundation, a refractory skeleton, on the ground that the task of the applicant is to carry abstraction to the utmost limit consistent with excluding the known articles. This, as it stands, is misleading, because it does not represent the whole truth. If cerium and thorium salts are the only salts which will fulfil the objects of the invention, then a claim which covers more than these is invalid on the ground of insufficiency in that the specification does not sufficiently describe how to carry out the invention with salts other than those mentioned. The writer of the book is well read, and he draws upon all classes of works in these pages, as, for example, the works of Anatole France, Spencer's "Study of Sociology," Theophile Gautier, Souriau's "Théorie d'Invention," Whewell's "Philosophy of the Inductive Sciences," Darwin's "Origin of Species," and the Reports of Patent Cases. The substance of the book having already been published, as has been explained, it is hardly necessary to deal with it, but there is one point which might be mentioned, namely, that it is said the 1919 Patents Act provides that relief may be granted on one claim of a patent, even though other claims may be invalid. The law is frequently misinterpreted or interpreted in a misleading manner in this way. The Act states that relief must be granted in the sense that if the Court find that any one or more of the claims in a specification is valid it shall grant relief in respect of any of such claims as are infringed without regard to the invalidity of any other claim, the discretion of the Court lying in the direction of costs, the date from which damages should be reckoned and terms as to amendments which it may deem desirable.

Mr. G. Hönnicke, of Cassel, was encouraged to compile his monograph on the construction of steam vessels and cognate apparatus, entitled "*Handbuch zum Dampffass-und Apparatebau*" [Berlin: Julius Springer, price 15 gold marks], by recent cases of peculiar boiler corrosion, suggesting faulty design and construction. The subject is very wide, and he restricts himself to cylindrical, spherical and rectangular steam vessels, boilers, autoclaves, digesters, separators barrels and pipes, mainly of steel and copper. Various metals are considered in reference to the question, such as aluminium, brass, bronzes, nickel, lead, tin. The volume of 205 pages, with 213 text figures, is eminently practical and largely tabular, 114 tables giving dimensions, wall thickness, shape, weight, &c., for various capacities and temperatures. Particular attention is paid to curvature, welding, riveting, flanges, couplings, joints, packing and connections. Most of the tables are drawn up by the author. The metrical system is used throughout, except as regards screw gauges, but the book will be appreciated outside the exclusive domain of that system.

Time was when engineering products were largely the outcome of the fertile brain of the principal or manager of an engineering works, and were subsequently sketched and dimensioned "from life" for record purposes. Later, an attempt was made to make the sketches first and the mechanism afterwards, a practice which in time led to the establishment and development of a separate department, out of which has grown the modern drawing office. In those early days the drawing office was regarded by many as a necessary evil, and for long the work of the office was limited to the making of broad outlines of design with some principal details and a few leading dimensions, all else being left to the powers and intuition of the works foremen. These times have now passed, and to-day it is recognised that a highly efficient drawing office, where the work is planned and worked out to the last small detail, is an essential part of every progressive industrial establishment. In "*Drawing Office Practice*," by H. Pilkington Ward, M.Sc. (London: Sir Isaac Pitman and Sons, Limited; price 7*s.* 6*d.* net), the reader will find in very complete detail how such a drawing office may be worked; its relations to and influence upon other works departments; the necessity for a simple and reliable working system; the qualifications and duties of the personnel, &c. Emphasis is laid upon the value of workshop experience in the training of a skilled draughtsman, and, again, that the holding of a university degree, while valuable and always desirable, does not of itself qualify a man for a draughtsman's position. Technical ability on the part of the draughtsman must be backed up by sound judgment, the faculty of putting ideas clearly on paper, and seeing the problem from the "other man's point of view." To many it is a matter of surprise that vertical drawing boards and draughting machines generally are not popular, but the fact remains, as brought out by the author, that the average draughtsman prefers the horizontal board, slightly inclined, over which he can lean. Uniformity of method in the lay-out and production of drawings in detail are features of almost every drawing office, and usually give to the office a characteristic of its own. It is not possible in a book of this kind to cover the practice in every office, or even in many, for the variety of work in different offices is infinite, and each office practice must be adjusted to suit, but the author has succeeded well in presenting those features which must be present in all offices if they are to be worked successfully. We would suggest to the author that linen covers for the boards, as is the practice in some offices, would be an improvement on the brown-paper sheets he advocates. It is also the case that in some offices a hand printing machine forms part of the outfit and is used for putting titles on drawings and tracings, and the printing of all works forms, notices, &c. There appears to be room for the extension of these practices.

Among recent monographs of the Sammlung Göschen we may notice the "*Eisenhüttenkunde*, Vol. I "*Roheisen*," by Dr.-Ing. M. von Schwarz, and the "*Elektrische Messtechnik*," Vol. I, "*Elektrische Messmethoden im Allgemeinen*," and "*Radiotechnik*," Vol. I, both by Professor J. Herrmann. Dr. von Schwarz is professor at München, Herrmann professor at Stuttgart. These little volumes, which are published by Walter de Gruyter and Co., Berlin and Leipzig, at 1·25 gold mark each, bound in cloth, are not all of uniform value. But what is said in these three books of about 125 pages on pig-iron, methods of electric measurements and radiotechnics, is certainly much to the point, and there is no waste of words.

THE ROYAL SANITARY INSTITUTE.—It is announced that the 36th Congress and Health Exhibition of the Royal Sanitary Institute will be held, at the invitation of the Magistrates and City Council, in Edinburgh, from July 20 to 25, 1925. A Congress will be held in London in July, 1926, to celibrate the Jubilee of the Institute.

EQUIPMENT FOR DRAUGHTSMEN.—The magnetic properties of the recently-discovered cobalt steels, have been utilised in an ingenious manner to provide a drawing board and T-square, such that the latter does not require to be held in position when drawing is in progress. This object has been accomplished by fixing light-weight metal strips along the left-hand side and bottom edges of the board and in the head of the T-square. No magnetic keeper or other apparatus of any kind is used. A further advantage incorporated into the T-square is the specially-bevelled longitudinal under edge, which allows of a drawing pin being smoothly passed over on the board. These improvements are being introduced by Messrs. Axene, Limited, of Maxwell House, Arundel-street, Strand, London, W.C.

CATALOGUES.

Lightning Conductors.—A catalogue of all the necessary parts for fitting up lighting conductors on buildings and chimney stacks has been received from Messrs. W. J. Furze and Co., Limited, Traffic-street, Nottingham. Prices and useful practical notes are given.

Motor Tractors.—A catalogue showing several standard designs of petrol-engined motor tractors for yard, warehouse and workshop use is to hand from Messrs. Bramco (1920) Limited, St. Nicholas-street, Coventry. These tractors are supplied for use on roads or rails.

Hydraulic Turbines.—Messrs. Boving and Co., Limited, 56, Kingsway, London, W.C., have sent us copies of their latest water-power plant catalogue, in English and Spanish, dealing mainly with very large installations and containing some impressive illustrations of pipelines and plants supplied by the firm to various parts of the world.

Refuse Destructor.—A catalogue of a refuse destructor capable of consuming 7 cwt. of refuse a day has come to hand from Messrs. Hardy and Padmore, Worcester. The whole plant may be turned round so that the air inlet will face the wind, and simple means for consuming the smoke and protecting the outer casing are provided. All the main parts are of cast iron.

Door Fittings.—A catalogue of metal fittings for folding, sliding and hanging doors, including brackets, runways, latches, checks, &c., has been received from the Richards-Wilcox Canadian Co., Limited, who are represented in this country by Messrs. E. Hill Aldam and Co., Limited, 93, Stamford-street, London, S.E. Stocks are held at the London address.

Boiler-Water Circulator.—A descriptive account of the Hotchkiss circulator, for circulating the water in steam boilers and extracting the air, oil and mud, has been issued by the makers, Messrs. Arthur Ross Hotchkiss and Co., Limited, 1, Glengall-road, Old Kent-road, London, S.E. The notes explain the advantages, both with respect to safety and economy, of keeping boilers clean and ensuring good circulation.

Weighing Machines.—The new edition of their general catalogue issued by Messrs. W. & T. Avery, Limited, Birmingham, contains additional items such as weighing machines of the visible-scale type with dormant platform for predetermined loads and for counter use. Some of these include price calculating indicators. The contents of this catalogue range from the heaviest weighbridges and locomotive weighing and balancing machines, to the finest bullion, jewellery, assaying and apothecaries scales; between these extremes a great variety of scales for general commercial use, is included. Semi-automatic weighing and counting appliances for many industrial purposes are also dealt with.

Engines and Boilers.—Messrs. Joseph Foster and Sons, Preston, Lancs, have sent us an album of thirty large illustrations of their products, which include steam engines, boilers, steam-driven gas compressors, high-pressure tanks and air vessels, timber impregnators, mixers, reduction gears, pulleys and toothed wheels, heavy castings, and cast-iron panels with machined edges for constructing tanks. Interesting illustrations are included of beam engines, both single-acting and double-acting, some of which run at 15 revolutions per minute, and have steam cylinders, 36 in. in diameter with a piston stroke of 7 ft. Some excellent views are also give of tandem and cross-compound engines and of engines of the triple-expansion type.

Life-Saving Apparatus.—A particularly interesting catalogue received from Messrs. Siebe, Gorman and Co., Limited, 187, Westminster-bridge-road, London, S.E., is divided into 17 sections, dealing with appliances for use in warfare or in industrial organisations under conditions involving danger to life or health. A large part of the catalogue is taken up with breathing apparatus for protection against the poison gases used in warfare, or generated normally, or otherwise, in mines, chemical works, storage tanks, ships, &c. Protective devices for covering the hands, face and, in some cases, the whole of the worker's body, are also dealt with. Various instruments, signals, lights, pumps, valves, gauges, vessels, &c., required are made in special materials and of sizes and weights suitable for all conditions, and the apparatus has also been designed, in many cases, to facilitate preliminary efforts at rescue, which may be made while preparations are in hand for more elaborate operations.

THE ROYAL PHILOSOPHICAL SOCIETY OF GLASGOW.—The recently published Proceedings of the Royal Philosophical Society of Glasgow for the years 1922 to 1924 afford evidence of the varied character of this body's activities. In addition to the general meetings of the society, sectional meetings are held for the discussion of economic science, historical and philological questions, and biological subjects. Of the 15 papers selected for publication in this volume there is a contribution by Professor A. L. Mellanby on "Theories of Steam Flow," in which he has dealt with the physics of the actions in steam nozzles and the effects of super-saturation. In a paper read by Dr. J. W. French on "Optical Glass" the author first gives an historical survey of the subject and then treats of modern practice and the effects of composition and treatment on the optical properties of the product. Other contributions of scientific interest have been provided by Professor A. O. Rankine, who lectured on "Speech Transmission by Light and Allied Problems," Professor J. Graham Kerr, who discussed "Science—the New Philosophy," and Professor Forsyth J. Wilson, who dealt with "Historical Aspects of Chemistry."

THE APEX PNEUMATIC CO_2 METER.

WHATEVER means are resorted to in the determination of the carbon di-oxide contained in flue gases they must be simple and certain in action, and the apparatus used must have little in it liable to get out of order. In such installations as the boiler houses of large power stations it is possible to resort to expensive instruments for the purpose, but that is not the case where the plant in question is small, such as that used for small steam stations and also for central heating plants. To meet this demand a simple and inexpensive instrument has been devised by the Uehling Instrument Company of 473, Getty-avenue, Paterson, New Jersey, U.S.A., which is illustrated by Figs. 1, 2 and 3 on this page.

This instrument, called the Apex pneumatic CO_2 meter, works on the principle of measuring the change in pressure of flue gas before and after the removal, by absorption, of the carbon di-oxide contained in it. In the actual instrument the pressure of the flue gas is not really measured, because the conditions of inlet flow to the instrument are maintained constant at all times. All that is, therefore, necessary to detect the amount of CO_2 in the flue gas, is to show the difference in pressure between the flue gas when freed from its CO_2 and the atmosphere. This is done by the use of a simple manometer, with which a calibrated scale is provided, so that readings may be obtained directly in percentages. The principle on which this instrument works may be judged from Fig. 1, which shows a diagrammatic sketch of the arrangements. The gas is drawn from the flue space in the boiler through what is termed a Pyro-porus filter. This is illustrated in Fig. 2 and is used to ensure the freedom of the gas drawn for the test from soot and fine ash. The filter is fixed to the end of the sampling tube. From the sampling tube the gas is drawn through a small drier containing calcium chloride. Drying is, of course, useful in reducing, or even eliminating altogether, the destruction of the piping, and permits the use of tubing of small diameter. The suction to draw the sample is created by an aspirator connected to the outlet of the instrument and is so arranged that constant flow conditions are maintained. A reference to the manner in which this is done will be deferred until after the working of the instrument itself has been described.

The sample enters the instrument by a pipe marked gas inlet, in the illustration, Fig. 1, and first passes through a porous thimble, C, which has the property of absorbing on its outer surface the objectionable sulphur constituents of the gas, and also, by its resistance, reduces and damps out the small variations in pressure in the sampling tube caused by varying chimney draught. From here there are two paths for the gas, one through the instrument proper and the other, a bye-pass, provided with an oil seal ensuring a constant suction pressure. The gas to be tested passes through a constricted opening, X, down to the foot of the long cylinder and then rises through a dry cartridge which absorbs the CO_2. The material of which this cartridge is composed is know as Natron, the active constituent being sodium hydroxide. In this passage the pressure of the gas is changed since the CO_2 is removed. When the gas reaches the top the absorption is complete, and it is from the pressure at this point that the amount of CO_2 removed is deduced. In proceeding out of the top of the absorption cylinder the gas has to pass through a second constricting tube Y, from which it emerges into the gas outlet pipe. The manner in which a manometer tube may be used to gauge the quantity of CO_2 in the gas from this pressure is shown in the illustration, Fig. 1.

In some cases single readings at definite periods are not so much desired as continuous records. For this purpose a pipe connection is taken from the tube connected to the manometer in Fig. 1 and the gas in it is allowed to exert its pressure on mercury in which there is a floating bell. As this float has a fixed quantity of air trapped within it, its depth in the mercury depends upon the pneumatic pressure which it is desired to measure and the actual movements are conveyed to the pen on the recorder drum. The form of an actual meter is shown in Fig. 3, where the kerosene-containing vessel used as the oil seal is shown within a perforated case. The absorbing cylinder case is the long narrow one on the left and the various connections are all mounted on the top. The porous thimble in the apparatus needs attention once or twice a year, but where there is much sulphur present it is advisable to clean it once a month, while the absorbent cartridge gradually loses its power and needs replacement, but it has a guaranteed life of 1,000 working hours.

The instrument having now been dealt with, it is necessary to explain how the suction of the gas through it is maintained constant. It has already been noted that constricted openings are used for the gas passage into and out of the apparatus, and these with the suction regulator have the effect of maintaining a regular flow of the gas and tend towards the maintenance of steady conditions, but it should also be understood that the drop of pressure through the whole apparatus is made constant by the use of a regulator on the aspirator which is connected to the outlet of the instrument. This regulator consists of a long vertical cylinder to the top of which the connections from the apparatus and to the aspirator are made. Water is passed into the vertical cylinder, where it is maintained at a fixed level by an outflow pipe. A long narrow inlet air pipe open to the atmosphere at the top and connected to the cylinder at the foot allows air to enter the cylinder whenever the suction becomes excessive. Automatic regulation of the suction is thus effected and it is preserved at a constant value at all times.

It will be observed that in this instrument there are no levers or springs to cause trouble and that the accuracy of its action will depend solely on the maintenance of the same amount of opening in the constricting tubes. As provision is made to prevent anything getting through to these tubes, which might be deposited in them, satisfactory and regular action may be expected. The apparatus may be erected to give indications to the fireman at the boiler and at the same time to the station superintendent in his office.

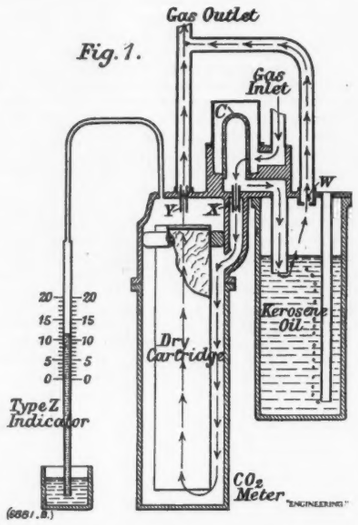
SINGLE CRYSTALS OF COPPER.—By the very slow heating of copper, followed by very slow cooling, Dr. Wheeler P. Davey, of the General Electric Company Research Laboratory at Schenectady, has succeeded in obtaining a single copper crystal nearly an inch in diameter and 6 in. long. A bar of pure copper is placed in a closed cylindrical carbon crucible and slowly passed through the furnace; the whole melt may consist of only one crystal, as proved by X-ray examination. A piece of this copper, of the size of a lead pencil, bent as easily as a stick of soft sealing wax; to bend it back, however, required as much force as an ordinary copper rod would need. The bending, it is suggested, forces the atoms on the lower surfaces together and those on the upper surface apart; the piece then changes in the surface layer into an ordinary piece of copper consisting of many small crystals. Filing and polishing also destroyed the single crystal, but etching with acids did not modify the crystalline structure though it was frequently found that the acid attacked the copper less along lines parallel to the optical axis of the crystal than in other directions.

THE S.S. HUMBER ARM.—The S.S. Humber Arm, a vessel specially designed for the carrying of paper in bulk, built to the order of the Newfoundland Export and Shipping Company, Limited, was successfully launched from the Walker Shipyard of Sir W. G. Armstrong, Whitworth and Co., Limited. The vessel is of the single-screw type, and has two decks with complete superstructure and forecastle, and was constructed to the requirements of Lloyd's Registry for their highest class. Carrying a total deadweight of 8,600 tons, the draft is 26 ft. 7 in., while a speed of 12 knots on a loaded trial has been obtained. The principal dimensions are: length, overall, 439 ft.; moulded breadth, 56 ft.; and moulded depth to upper deck, 39 ft. The vessel is specially designed for the conveyance of reels of paper, carried in the lower holds and between decks. Cargo-spaces have been arranged with a view to securing a minimum of waste space. In view of the particular service intended the bow and stern of the vessel have been specially strengthened for working in ice. A cellular double bottom has been fitted fore and aft, for the carriage of oil fuel or water ballast. The fore and aft peaks and two deep tanks have been arranged for water ballast. The pillar arrangement has been specially considered in order to obtain a hold clear of obstructions. Every precaution has been taken to prevent damage to the paper reels in transit. The vessel is fitted with 18 steam winches, of the two-cylinder, horizontal type. The steering gear is of the Wilson-Pirrie type, fitted direct to the rudder head, and controlled by a telemotor from the wheel house amidships. Two steel masts have all the necessary fittings for derrick and cargo gear. The electric lighting installation comprises a direct-coupled generating plant complete with a vertical, single-cylinder engine of ample power to run the whole plant at one time, and a dynamo, the latter of the multi-polar type. The propelling machinery is of the triple-expansion type, the engine having cylinders 28 in., 46 in., and 77 in. in diameter, the stroke being 51 in. Steam is supplied by three single-ended boilers, 16 ft. 6 in. diameter and 12 ft. long, working at a pressure of 180 lb. per square inch. Howden's forced draught has been adopted, and coal or oil may be burned. The propelling machinery is being constructed by Sir W. G. Armstrong, Whitworth and Co., Limited, at their Marine Engine Works, Elswick.

THE APEX PNEUMATIC CO_2 METER.

CONSTRUCTED BY THE UEHLING INSTRUMENT COMPANY, PATERSON, N.J., U.S.A.

Fig. 1.



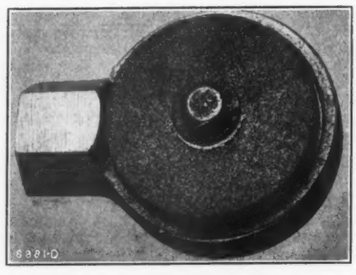


FIG. 2. PYRO-POROUS GAS FILTER.

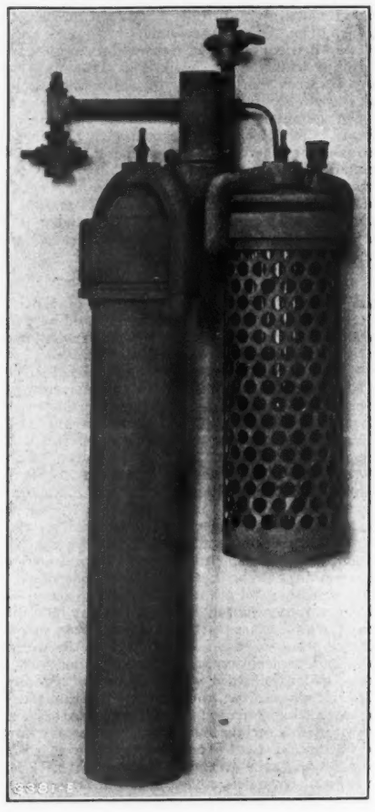


FIG. 3. ABSORPTION VESSEL AND OIL-SEALED BYE-PASS.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

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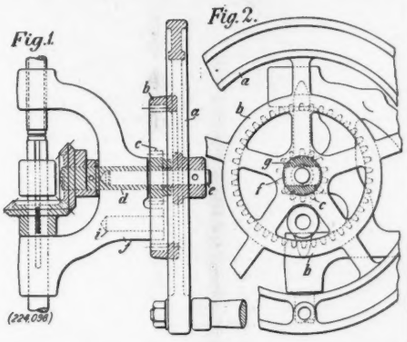
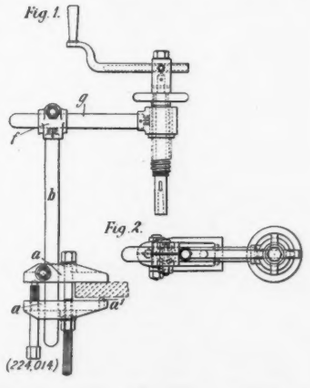
MACHINE AND OTHER TOOLS, SHAFTING, &c.

224,098. H. Boothroyd, Heckmondwike. Variable Speed Gears. (4 *Figs.*) November 24, 1923.—The invention relates to two-speed gears of the kind comprising an adjustable internally-toothed driving wheel which may be moved into or out of engagement with a toothed pinion according to the speed required. *a* represents the handwheel of a bench drilling machine, *b* the internal gear associated therewith, and *c* the pinion mounted on the driving shaft *d*. The driving shaft *d* is bored to receive the pin *e* carrying the hand wheel. On the face of the hand wheel and concentric with the pin *e*



are two oppositely disposed projections *f* adapted in one position of the hand wheel *a* to engage projections *g* on the pinion *c*. When the hand wheel *a* is in the position whereby the projections *f*, *g* co-operate, the drive through the pinion *c* and shaft *d* to the bevel gears *h* will be direct or normal. By removing the hand wheel *a* and the pin *e* from the hollow shaft *d* and inserting the pin *e* into hole *i* in the frame *j* at such a position whereby the teeth of the gear *b* will mesh with the teeth of the pinion *c* on the shaft *d*, the pinion *c* may be driven at an increased speed according to the gear ratio of the internal wheel *b* and of the pinion *c*. (*Sealed.*)

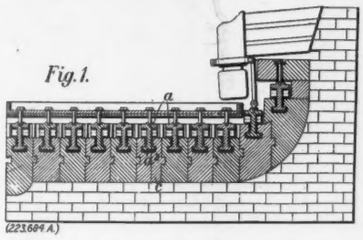
224,014. T. H. L. Dixon, Letchworth, and T. H. Dixon and Co., Limited, Letchworth. Portable Drilling Machines. (2 *Figs.*) August 15, 1923.—The invention has reference to stands for portable drilling machines of the kind wherein the drill spindle is capable of being adjusted for use in different angular positions relatively to the stand by which it is adapted to be supported on the structure to be drilled. Accord-

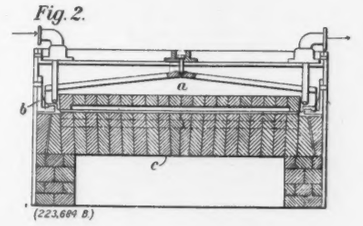


ing to the invention, the adjustable member *g* and the post *b* forming part of the stand are made of rolled steel alloy and the part *f* for adjustably connecting them together, and the clamping plates *a* for securing the drilling machine to the structure, are constituted of malleable iron or steel alloy castings. The clamping plates or blocks *a* are provided with adjustable or other studs a^1 to enable them to be attached to a structure having uneven or irregular surfaces in such a manner as to ensure a firm and secure grip being obtained by the clamping plates or blocks. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

223,684. L. Morton, London, and J. Hargrove, Tettenhall. Furnaces. (20 *Figs.*) August 8, 1923.—The improvements relate to suspended furnace arches or suspended fire-brick liners for furnaces. In carrying out the invention, a series or number of arch-bearer bars *a* is employed. Below and preferably formed along with the arch-bearer bar *a* is a second or bottom rib a^2 running horizontally. The bottom rib a^2 is recessed towards each end to permit the fire-bricks to be threaded or strung thereon. The arch-bearer bars *a* are supported by brackets *b* attached to the furnace walls. Between

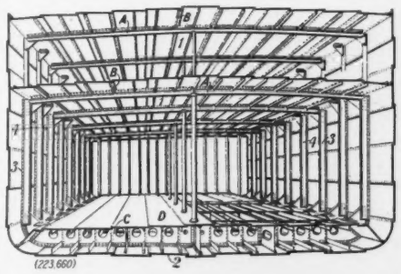




the top and bottom ribs of the arch-bearer bars *a* the fire bricks are threaded through the checked-out portions in the bottom rib of the arch-bearer bars and passed end-on along to the desired positions so as to abut together to produce a complete or lateral refractory area. The ranks of fire-bricks are combined, each supported from its arch-bearer bar. For the indicated purpose of threading, the bricks *c* have an "⊥" or suitably shaped channel formed therein. The bricks in adjacent ranks may interlock one rank with another. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

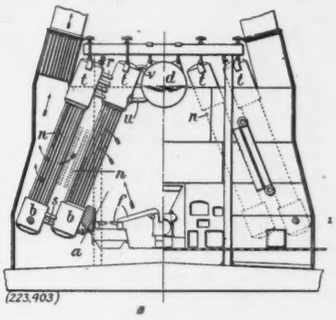
223,660. Sir J. W. Isherwood, Chislehurst, Kent. Ships. (3 *Figs.*) July 26, 1923.—The invention relates to a modification of the system of ship construction generally known by the name of Isherwood. According to the invention, a floating vessel has what is known as an Isherwood bottom structure, that is, one comprising strong transverse floors and longitudinals, and with an Isherwood deck structure comprising strong transverse beams and longitudinals, one of the beams being over each of the floors, and with shallow side frames which are more closely spaced than the floors and beams and none of which is reinforced, one of the frames on each side being in way of each floor and beam.



1 indicates the Isherwood deck comprising widely-spaced deep transverse members or beams A through the outer edges of which pass longitudinal members B of less depth, the deck being attached to the transverse and longitudinal members. 2 shows the Isherwood bottom comprising widely spaced deep transverse members or floors C through the outer edge of which (in the case of a single bottom) or through the outer and inner edges (in the case of a double bottom) are passed shallower longitudinal members D, the bottom plating in the one case and the bottom plating and tank top in the other case being attached to the said transverse and longitudinal members. 3 are the shallow side frames in way of the Isherwood transverse members, 4 the intermediate shallow side frames. (*Accepted November 5, 1924.*)

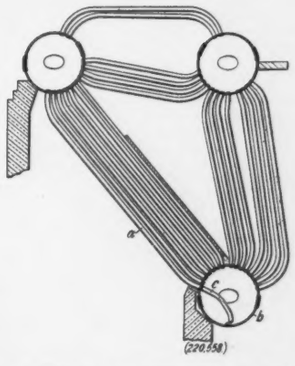
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

223,403. Richardsons, Westgarth and Co., Limited, Hartlepool, and L. Taylor, Middlesbrough. Water Tube Boilers. (3 *Figs.*) October 29, 1923.—The invention relates to water tube boilers of the type comprising a number of nests of steam-generating tubes, each nest being connected to a top header and to a bottom header, and a centrally disposed steam-and-water drum connected to the top headers. The invention is characterised by the arrangement of the nests of steam-generating tubes in two pairs of parallel rows which converge upwardly towards each other and enclose the combustion chamber, the steam-and-water drum being located



between the several top headers and serving to close in the combustion chamber at the top. *f* is the fire grate; *a* the combustion chamber; *n* the nests of water tubes; *b* the bottom headers connected together by tubes *s*; *t* the top headers connected together by tubes *r*; and *d* the steam-and-water drum which is connected to the inner top headers on either side by the steam tubes *v* and the water tubes *u*. The products of combustion from the fire grate take a course as indicated by the arrows. The construction provides a high and large combustion chamber and also enables the steam generating tubes to be withdrawn through the upper headers and into the chimney. (*Sealed.*)

220,558. The Stirling Boiler Company, Limited, Westminster, London, and H. J. S. Mackay, London. Water Tube Boilers. (3 *Figs.*) February 7, 1924.—The invention relates to water-tube boilers having upper steam and water drums and lower or mud drums. In



accordance with the invention, there are fitted to a number of the main tubes *a* entering the mud drum *b* and extending over the fire, extension pieces *c* projecting nearly to the bottom of the drum, and in each of these extension pieces is fitted a steam jet device serving to induce an upward circulation in the tubes. (*Sealed.*)

222,218. Babcock and Wilcox, Limited, London, and A. Spyer, London. Oil Burners. (3 *Figs.*) June 29, 1923.—The invention relates to impeller rings for use in connection with liquid fuel burners. The impeller ring, according to the invention, comprises a narrow annulus to which are welded or otherwise secured the outer longitudinal edges of a number of flat, wide, radially-disposed and widely-separated, inwardly-tapering blades, each having parallel inner and outer longitudinal edges, one inclined lateral edge disposed on a conical surface coaxial with the annulus and the other lateral edge being perpendicular to the outer and inner edges and in a plane perpendicular to the axis of the annulus. Each blade as a whole is inclined to the said axis, the blades being so arranged as to give the air passing between the blades a rotational or vortex movement. The impeller ring comprises a narrow annulus A to which are welded, or otherwise secured, portions of the outer longitudinal edges of a number of flat, wide, radially disposed and widely separated inwardly tapering blades B, each having parallel inner and outer longitudinal edges C and D, a lateral edge E inclined to the longitudinal edges and a lateral edge F perpendicular to the

longitudinal edges, the edges E of all the blades lying on a conical surface coaxial with the annulus, and the other lateral edges F of all the blades being in a plane at right angles to said axis of the annulus. The blades are inclined to the said axis and so arranged as to give the air passing between the blades a rotational or vortex movement. It will be seen that the annulus may be secured in position in the existing air register G by means of set screws H. (*Sealed.*)

Fig. 1.

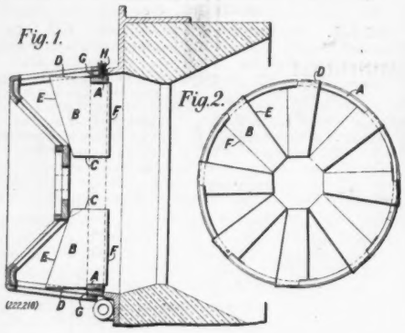
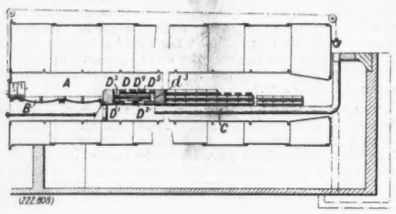


Fig. 2.

222,808. J. Ogden, Reddish, Stockport. Boiler Furnaces. (3 *Figs.*) July 12, 1923.—The invention relates to furnaces for boilers of the Lancashire, Cornish or similar type. The furnace tube A is of ordinary construction with fire-bars B and a checkered fire-brick wall behind the fire-bridge D formed to allow of the air passing up through it to the furnace. A pipe C extends from the rear end of the boiler along the flue A to the fire-bridge D. Air entering through this pipe C is pre-heated and is discharged into the furnace below the fire-bridge D. The preheated air passes through the spaces between the bricks D^1 forming the lowest course and impinges upon the baffling bricks D^2 forming the second course. These baffling bricks D^2 are shaped and



arranged to give a tortuous flow to the air and cause it to move to the rear of the bridge. The third course D^3 is formed without any spaces between the bricks, a slot d^3 being left at the rear end thereby causing all the air to travel along the underside of this course to the end of the bridge. The course D^4 is made up of bricks arranged in longitudinal lines, with spaces between adjacent rows forming passages through which the air can pass. A transverse course D^5, also with spaces between adjacent rows, is placed on top of the course D^4 thus forming apertures through which the air emerges to mix with the gases passing over the bridge from the furnace. The height of the bridge can be varied by varying the number of checkered courses built above the course D^5. (*Sealed.*)

223,680. W. F. Goodrich, London, E. H. Skinner, Romford, and Vickers-Spearing Boiler Company, Limited, London. Chain-grate Stokers. (4 *Figs.*) August 3, 1923.—In a mechanical stoker the endless chain grate comprises, according to the invention, a number of fuel-carrying links, each of which has a series of separate or distinct fuel-carrying faces and is so assembled that normally the same face thereof is always presented to the fuel, and that, when desired, it can be rotated, while in position in the grate, to permit of another face being presented to the fuel. The endless chain is formed by a number of reversible links 1 mounted on rotatable transverse rods 2 and connected together through driving links 3, the whole being carried by drums 4, 5 at opposite ends of the grate. The chain-grate links 1 have square apertures through them for the reception of the rods 2, which are of similar section but have their corners rounded for rotatable engagement with the driving links 3, which are interposed at suitable points in each transverse row of links 1. The arrangement is such that the surfaces of the links 1, 3 form a continuous and smooth fuel-carrying surface while passing through the furnace. The driving links 3 have inwardly-projecting arms 7, carrying pins 9, by which they are connected to form endless driving chains. Mounted on the pins 9, intermediate the arms 7, are rollers 10. The driving drums 4, 5 are of polygonal section and are provided with teeth 11 to engage the rollers of the driving chains. Interposed between the drums 4, 5 are transverse box girders 12, carrying rails 13, upon which the rollers 10 travel. The links during their travel along the lower portion of the furnace are supported by rollers 14. Mounted on the faces of the driving drums 4, 5 towards one end thereof, are box-shaped members 15, each pivotally secured thereto and provided with a locking device, the box members being so positioned that while their outer faces engage the inner surfaces of certain of the reversible links during the latter's travel round the driving drum, they do not intercept the path of any driving chain. By this means inadvertent tilting or reversing of the links is prevented. In operation, when it is desired that one row of the chain-grate links should be reversed owing to one of its faces being burnt or worn out, as this row

Fig. 1.

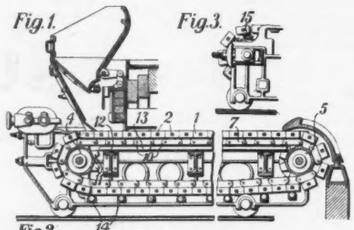
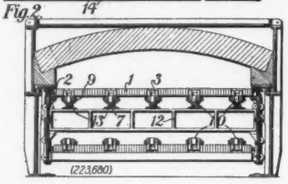


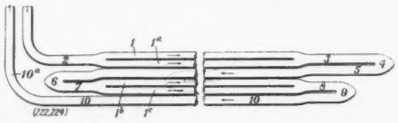
Fig. 3.

Fig. 2.



of links comes to a position registering with the face of one of the box-shaped members 15, the locking device is loosened and the member is swung outwards, whereby on turning the rod 2 of that row of links the whole row can be readily reversed. The member 15 can then be returned and secured. By reason of the rod 2 having its corners rounded, it can be freely rotated in the driving links.—(*Sealed.*)

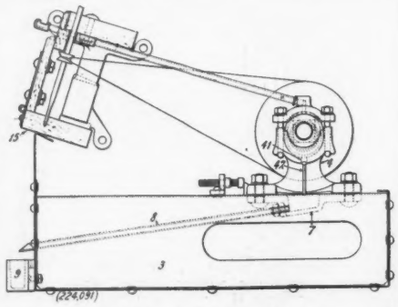
222,224. H. A. Stenning, London, and Marine and Locomotive Superheaters, Limited, London. Steam Superheaters. (5 *Figs.*) June 30, 1923.—The invention consists in improvements in steam superheaters of the smoke or fire-tube type in which U-loop superheater elements extend into smoke or fire tubes of a boiler. According to the invention, the portion within the smoke tube comprises a number of lengths of pipe for conveying steam in one direction, for instance, towards the firebox or furnace, and a series but different number of lengths of pipe for conveying steam in the opposite direction, for instance, towards the smoke-box or uptake, there being only two pipe ends to be connected to the steam distributing and collecting chambers in the



smoke-box or uptake. 1, 1*a* are two lengths of pipe, the ends of which adjacent to the smoke-box are connected to a short pipe 2. This is connected to the saturated steam chamber. The ends of the pipes 1, 1*a* adjacent to the fire-box are connected to a single short length of pipe 3, which is connected by a return bend 4 to a single return pipe 5. This pipe 5 is connected by a return bend 6 to a short pipe 7, to which are connected two lengths of pipes 1*b*, 1*c*. The pipes 1*b*, 1*c* are connected to a short pipe 8, which is connected by a return bend 9 to a superheater steam outflow pipe 10, the outlet end portion 10*a* of which is located in the smoke-box and adapted to be connected to the superheated steam chamber.—(*Sealed.*)

TEXTILE MACHINERY.

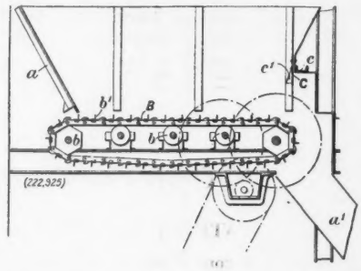
224,091. Platt Brothers and Co., Limited, Oldham, and H. P. Hall, Oldham. Self-acting Mules and Twiners. (1 *Fig.*) November 10, 1923.—The invention relates to means for collecting lubricating



oil escaping from the bearings of tin roller shafts in self-acting mules and twiners. The mule carriage shown is constructed of sheet metal plate and channel bars and supporting the spindle rail 15 at the front carries, bolted on a channel bar 3, the tin roller bearing bracket 4. Secured within the channel bar 3 is an oil receptacle 7 having its floor inclined towards the front of the mule carriage. A pipe 8 is screwed into the receptacle 7 and extends inclining downwards through a hole in the front of the carriage. The outer end of the pipe 8 is chamfered and overhangs a cup 9 detachably secured on the front of the mule carriage. The tin roller bearing bracket 4 which is formed with a cavity to receive the bearing and to catch oil dripping therefrom is provided with a hole 41 leading to one side of the bracket which is provided with a groove 42 for guiding the oil escaping from the bearing and issuing from the hole 41 into the receptacle 7, whence it flows through the pipe 8 into the cup 9. (*Accepted November* 12, 1924.)

MISCELLANEOUS.

222,925. Heenan and Froude, Limited, Worcester, and R. C. Wareham, Worcester, and J. Jackson, Moseley, Birmingham. Refuse Destructors. (6 *Figs.*) July 4, 1923.—The invention relates to devices for feeding refuse at a slow rate from the hoppers or bins in which it is stored in bulk, of the type in which an endless band is fitted below the hopper, to carry the material forward through an adjustable delivery aperture. The invention consists in a travelling band in the bottom of the hopper with upstanding projections at intervals to engage the refuse and carry it to the delivery end of the hopper. The delivery end of the hopper has an adjustable device to regulate the amount



of refuse allowed to pass and a chute to deliver the material forward. The hopper has slightly inclined sides *a* to support a part of the weight of the refuse, the outlet a^1 for the delivery of the refuse being arranged at one end of the hopper. An endless travelling band B is carried on sprocket pulleys *b*, and this band B is provided at intervals with projections b^1 which engage the refuse and carry it to the delivery outlet a^1. The delivery end of the hopper is formed with an adjustable feed-regulating device C affixed to a bracket *c* and carrying a projecting member c^1. This regulating arrangement is placed above the band B to prevent too much refuse being carried forward and thereby causing a jamb at the outlet a^1. (*Sealed.*)

223,319. G. F. French, Manchester. Belt-Tensioning and Fastening Appliances. (16 *Figs.*) July 21, 1923.—The invention refers to tensioning and fastening appliances for belts, bands or straps. According to the invention, the improved appliance comprises an arrangement of two cross-rods *b*, *d*, to one, *d*, of which one end of the belt *e* is permanently secured, and with the other, *b*, of which the other end of the belt is adapted to engage when requiring to tension the belt. It also comprises an arrangement of a pivoted link D and a lever A, each carrying one of said cross-rods, the lever also carrying a sliding cross-bar *c*. The link D is pivotally connected to the lever A, either directly or through the cross-bar *c*, in such manner

Fig. 1.

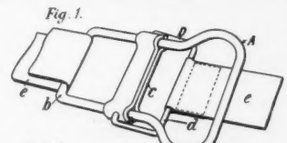
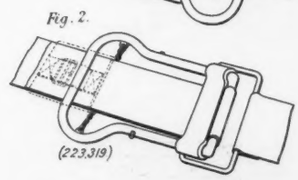


Fig. 2.



that on the lever being rotated in one direction the belt is gripped by the cross-bar and tightened, while on the lever being moved in the reverse direction the cross-bar releases the belt and allows it to slacken. In order to utilise the tensioning devices for also fastening the belt (*i.e.*, preventing the belt slackening after tensioning), the link D and its pivots are arranged so that when the lever is rotated beyond a given extent, a "toggle" is formed, the pull of the belt causing the lever, after the link pivots have passed over a "dead" centre, to maintain the "toggle." Additional means may, if desired, be provided for locking the lever and link against accidental displacement after the "toggle" is made. (*Sealed.*)